A Brief

DESCRIPTION

OF A

NEW INVENTED, SMALL, yet ACCURATE

Astronomical Quadrant.

Particularly calculated for

Curious Observations at SEA,

But equally useful at LAND:

AND THAT

Either by DAY or by NIGHT.

Together with some useful

PROBLEMS for finding the *LATITUDE*

In Failure of a Meridian ALTITUDE;

Propos'd in such a Manner as to make the Calculation Easy and Expeditious; and freed from some Errors they were before liable to.

WITH

MAPS of the STARS,

Laid down in a different,

But more intelligible Manner than usual, and design'd as a Guide to the Knowledge of them.

By *ELIAS PLEDGER.*

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[Price Two Shillings.]

THE

PREFACE.

N*AVIGATION, tho' it be one of the moſt uſeful and profitable Arts, has yet receiv'd leſs Improvement in this Age than any other Art whatſoever. And however ſtrange the Aſſertion may ſeem, yet this, in my Opinion, is greatly owing to the extravagant Rewards that have been offered to any Perſon, that ſhould ſolve the* Grand Problem *of finding the* Longitude *at* Sea. *This like the* Philoſopher's Stone *hath ſet many Heads to work, and hath occaſion'd a Multitude of trifling and fruitleſs Schemes and Projects for the attaining of it; ſcarcely a Year paſſing without one or other's pretending to the Invention. And the World hath ſo often been diſappointed in its Expectations, when any Thing of this Kind hath been publiſh'd, that it hath occaſion'd the Neglect of many good Inventions propos'd together*

gether

gether with it, which might, in many other Cases, have been very serviceable. Almost all Inventions that have had any Tendency towards the Solution of the Problem, *have been generally kept in reserve by the Inventors, in hopes that hereafter they might turn to their Advantage. And thus the Means that perhaps were design'd to improve the Art, have occasionally proved a very great Hindrance to it: For it is not the Improvement of Navigation, but the Reward for finding of the Longitude that most People have had in View.*

Those who have been most skill'd in these Affairs, and have been most likely to publish any Thing of that Kind, have never yet attempted it; well knowing that besides the Difficulty of finding the Moon's true Place, there are also many other Things previously necessary to it. Such as, more accurate Instruments than any yet in use at Sea, for the Ascertaining the true Point of Time; Instantaneous, or at least, perfect *Observations for the Latitude. For* if these could be procured, *I make no doubt but that the best, at least the readiest way of finding the Longitude, would be by Means of a good Watch: Which is a Thing that is now brought to a very high Degree of Perfection, and may much more safely be trusted to, than the inaccurate and erroneous Altitudes and Latitudes with which it has been usually compared. But further, supposing the Longitude was actually found, and that to all the Certainty that could*

be

be desired; it would still be entirely unavailable for Practice, till the Longitude of Places *be truly laid down; for if there be any Possibility of Uncertainty in either, it will be very difficult to judge in which the Error lies.*

It were therefore greatly to be wisht that some publick Care might be taken concerning this very Thing in particular, for which there are already very easy and sufficient Helps proposed, by Means of the Eclipses of Jupiter's *Satellites. A Thing of great Use, but for Want of a moderate and reasonable Reward, too much neglected.*

The Things I have here propos'd in the following Papers have all of them some Tendency *to answer the necessary Ends I have been mentioning. The Quadrant being useful at Land as well as at Sea, is very well suited to find the true Time on Shore; by which to observe the Immersions or Emersions of* Jupiter's *Satellites; this would be a noble Entertainment to curious Commanders, whose Observations in the several Parts of the World, where their Occasions might lead them, would be of Service to the Publick.*

A Telescope of 13 *or* 14 *Feet would be very sufficient for the Purpose: And an Object-Glass of that Radius, with a suitable Eye-Glass would neither be very Chargeable nor Cumbersome; for they may be used without the Tube, and will be sufficient for Use, only by fixing them on any common Pole at the proper*

per Distance. I have my self in this Manner very plainly discern'd an Emersion of the first Satellite with an Object-Glass of no more than 10 *Feet in Length, and I do assure you that it is much the best Way, the Instrument being more manageable, and the Object more readily found, which is indeed the usual Objection against the common Tubes.*

I have divided the following Sheets into three Chapters, as they are three distinct Subjects; the first of which contains, The Description of the Quadrant, and Directions for the Making of it.

The Second treats of an Observation for finding the Latitude in failure of a Meridian Altitude.

And the Third, of finding the same Things by the Stars, by Means of several Schemes and Tables peculiarly adapted to it.

The particular Tables of the Stars, to be used in the Solution of the last Problem are exactly calculated *from the Places they will have about the Middle of* Nov^r^. 1731, *and will hold good for many Years to come.*

Their Distances thus found, do exactly agree with the Distances observed *by Mr.* Flamstead, *and may therefore safely be depended on.*

A Brief

DESCRIPTION

OF A

New-Invented Small, yet Accurate

Aſtronomical QUADRANT.

CHAP. I.

Containing the Deſcription of the Quadrant, *and Directions for the making of it.*

THE finding of the true Altitude of the Sun or Stars is of ſo great Conſequence in the Art of Navigation, for the Diſcovery of either the Latitude or Longitude; and there are ſo many other Problems entirely depending on the Knowledge of the Zenith Diſtance of any Phænomenon, that there cannot, in my Opinion,

be too much Pains and Curioſity beſtowed on any Inſtrument that is likely to anſwer that Purpoſe.

I have therefore turn'd my Thoughts that Way for ſome Years paſt, and have been endeavouring either to improve the Inſtruments now in uſe, or to invent ſome others that might be more eſpecially ſerviceable to Mariners. And finding particularly, that the common Quadrants are often uſeleſs, thro' the Want of a perfect Horizon; and that the Difficulties attending the Inſtruments proper for making Obſervations by Night, are ſo great, as wholly to diſcourage many from the Uſe of them; though in the Practice of Navigation, thoſe Obſervations are many times abſolutely neceſſary: I firſt reſolved on trying ſome Experiments in order to render the common Spirit-level uſeful for that Purpoſe; by applying it to a Quadrant, to anſwer the End of the Horizon. And having ſome ſmall Glaſs Tubes by me, I fill'd one of them, leaving a ſmall Bubble of Air. The Tube appear'd very ſtreight, and I deſign'd to have fix'd it to my Quadrant, in order to try the Experiment; but I found, by laying it on a Plane, that the Effect was very different, according as different Parts of the Tube were upward; for when one particular Part (which I marked) was upward, I found I could not make the Bubble reſt any where, but at either

ther End: And that raiſing the Plane, as ſoon as ever it began to move from one end, it would immediately run to the other, & *Vice Verſa.* I then try'd the contrary Side upwards, and upon raiſing the Plane again, I found the Bubble would then reſt in any Part of the Tube; and that by raiſing it, or depreſſing it a certain Space, it would always be moved in an equal Proportion. Upon which I took a Ruler, and laying the Tube upon it, I ſoon found that it was a little bent, and was indeed the Portion of a very large Arch; and that when the *Concave* Side was upward, I could by no means fix the Bubble any where but at either End; but when the *Convex* Side was upward, I could then readily fix it in any Part of the Tube at Pleaſure. The Reaſon was very obvious; and I was exceedingly pleas'd to think I had accidentally light upon a Method ſo very *à propos* to my Deſign, by which I could enlarge the Limb of my Quadrant to any Radius almoſt indefinitely, at leaſt ſo much of it as might be neceſſary and ſufficient for Practice. And immediately I went to a Glaſs-Houſe to get ſome Tubes that might anſwer my Turn; and examining ſome that were ready blown, I pick'd out ſome four or five that I thought might do, and trying them upon my Return, I found them all good; but particularly one of them was the Portion of an Arch near ſixty Foot Ra-

dius, which I found by fixing it to my Quadrant; for upon depreſſing it but one ſingle Degree, the Bubble ran very near one whole Foot; and very regularly and quickly reſted in any Part of the Tube, as I depreſſed my Quadrant little or much.

Theſe Experiments I made about the latter End of *May*, 1728. as I find by my Papers; upon which I put down the ſeveral different Runs of the Bubble in each Tube, which was dated *May*, 31 1728. I had now got what I had been ſeeking for, and accordingly I marked on my Tube every ſingle Minute of a whole Degree, and fix'd it to my Quadrant for Uſe. And I found it every way to anſwer my Purpoſe.

Shortly after I ſhew'd it to ſeveral of my Friends, who approved the Deſign, and I was then reſolved to perfect it; and have been at Times, ever ſince endeavouring to improve it, in order to make it particularly uſeful at Sea. But going out of Town, it lay dormant for ſome time; when about a Year after, I read an Advertiſement in the Papers, of a Quadrant for taking an Altitude at Sea without an Horizon; for which Mr. *Elton* had procured a Patent, and which was made and ſold by Mr. *Siſſon* in the *Strand*. I preſently imagined that my Invention had gotten Air, by means of ſome Hint given concerning it; tho' I had deſired my Friends not to divulge it, till I had brought it to greater

ter Perfection, when I design'd to publish it for a common Benefit. But upon going to view Mr. *Elton*'s Quadrant, I found I was mistaken, for that his was made only by applying two common Spirit-levels to a *Davis*'s Quadrant, somewhat alter'd to answer his Purpose, much after the same Manner I had first design'd: And that the Limb of his great Arch was divided as usual into Degrees and Minutes, and that his Glass Tubes answer'd no other End than to find a Level.

However, as he had gotten a Patent for his Quadrant, I did not doubt but that there would soon be Numbers of them made; and that in a little Time I should hear how they answer'd at Sea. And accordingly, upon Enquiry, I have since understood that in fine Weather they will answer pretty well; and therefore I concluded that mine, depending upon a Bubble as well as his, tho' upon quite different Principles, would answer all the Purposes I design'd by it much better, and be moreover useful by Night as well as by Day. I do therefore now offer it to the Publick, hoping that some valuable Ends may be answer'd by it.

The Description of the QUADRANT.

THE Quadrant which I now propose, may be made of any Material, and to any Size. But that which I caused to be made

made for my ſelf is of Box, and of the Semi-diameter of eighteen Inches; the Radii and Limb being about ſeven Tenths of an Inch thick. The Limb is divided to ſingle Degrees only, and number'd at each Diviſion. In Obſervation the Limb is always towards me, and the upper Radius nearly horizontal; and the Degrees begin with one at the perpendicular Radius, and end with 90° at the horizontal Radius.

To the Center is fix'd a Box-Ruler, that is an Inch and an half broad, and ſomething more than three Tenths of an Inch thick; the End of which ſlides on the Limb by means of a Braſs-Spring that goes half round it. In the End of the Ruler there is a ſmall ſquare Hole, juſt big enough to diſcover the Degree to which the Ruler is at any time fixed; and for that Purpoſe there is a fine Horſe-hair placed in it, exactly on the Line that is drawn in the midſt of the Ruler from the Center. On the Ruler are fixed three Vanes or Sights, being each about two Inches in the Perpendicular from it, about one Inch eight Tenths broad, and three Tenths and an half thick. The Middle of each Sight, is the Center of Holes of the following Diameters.

One Vane is fixed on the Ruler, at the Diſtance of about half an Inch from the Center; and in it is a Hole bored to receive an Object-Glaſs of about one Inch and two

Tenths

Tenths Diameter. To cover this Glaſs, there is a thin Braſs-Plate fix'd on a Center-pin, that is made to turn off or on at Pleaſure, with a Pin to ſtay it. In the Center of this Plate, anſwering to the Center of the Sight, there is a ſmall Hole or Aperture of two Tenths of an Inch Diameter.

In the Focus of this Object-Glaſs, towards the Limb, is placed a ſecond Sight, in which there is a plain Hole bored quite thro', of 1, 25 Inch Diameter; and on this alſo, there is a thin Braſs-Plate fix'd on a Center-pin, on that Face of the Sight neareſt the Center, made to turn aſide upon occaſion; and on the Plate is marked a perpendicular and a horizontal Line, which croſs each other exactly in the Center of the Sight. Turning aſide the Braſs-Plate, you diſcover three fine Horſe-hairs, which are alſo placed on that Face neareſt the Center; one of them Horizontal, the other two Perpendicular to it; one on each Side of the perpendicular Line that is marked on the Sight, at the Diſtance of ſomewhat more than an half Tenth of an Inch from, and parallel to it; being ſo placed to prevent a Star's being wholly cover'd by a ſingle perpendicular Hair.

The third Sight is placed at the Diſtance of about one Inch and ſeven Tenths from the Second, and about three Inches and an half from the End of the Ruler, which is rounded off, and is about half an

Inch

Inch beyond the outſide Limb of the Quadrant. In this Sight is bored an Hole of about one Inch and an half in Diameter, to receive an Eye-glaſs of that Size; and the Ledge of the Hole which the Glaſs reſts upon, is as ſmall as poſſible. The Focus of this Glaſs is two Inches, and the middle Sight muſt always be fix'd in the Focus of both.

On the upper Edge of the horizontal Radius, is a Groove near ten Inches and an half long; which is ſome ſmall matter deeper towards the Limb, than towards the Center, made to receive a Glaſs-tube of that length, and of about half an Inch in Diameter; which is the Portion of an Arch of about thirty Foot Radius. This Tube is fill'd with fine Spirits, and then ſeal'd hermetically, leaving only a ſmall Bubble of about eight Tenths of an Inch long. On the Tube is paſted a Paper, the Edge exactly along the Middle of the upper or convex Side. On the Edge of this Paper is marked the Run of the Bubble every ſingle Minute of about one Degree and an half; which was perform'd in the following Manner.

I firſt meaſured out exactly 50 Feet for my Radius, and ſeeking the Proportion of the Tangent of one Degree, by a Table of Natural Tangents, I found it 8,717 Inches, which 8 Inches and odd Parts, I divided exactly into 60 equal Parts, on a Paper's Edge, for the Tangents of each Minute of my Degree;

gree; and continued them to 90 Minutes ſufficiently correct. Having done this, I fixed the Paper in my Window exactly Perpendicular, and at the Diſtance of 50 Feet from it; and at the ſame Heighth I fixed a Plane moveable as on a Center, exactly at the Diſtance of 50 Feet from the Paper to the Center of Motion. On this Plane I fixed a Teleſcope of 3 Feet, with a curious ſingle Hair (drawn from Worſted) in the Focus of its Eye-glaſs; and placing my Tube, the Convex Side upwards, and parallel to the Teleſcope, and both perpendicular to my Paper; I could, by looking thro' the Teleſcope, readily fix the Point of the Hair to any ſingle Minute on the Paper, Half or Quarter: And ſo by gradually dropping that Part of my Plane neareſt mine Eye, (which was therefore made heavier than the other Part on the other Side the Center of Motion) I readily raiſed my Plane thro' the whole 90 Minutes; at the ſame Time diſtinctly marking the Run of that End of the Bubble, which I deſign'd ſhould be placed neareſt the Center of my Quadrant. And trying it afterwards, I always found, that where-ever I fix'd my Teleſcope, the Paper in the Window, and the Bubble on my Tube, would exactly correſpond.

The Tube thus prepared, is then fixed in the Groove; that End of the Bubble which I mark'd the Minutes by, neareſt the Center. And mine is ſo placed, that when the upper

C Radius

Radius is exactly Horizontal, the Bubble will then reſt within four or five Minutes of that End of the Tube which is neareſt the Center; and at that very Point the Minutes of my Zenith Diſtance begin to be marked, proceeding from thence onward to ſixty Minutes neareſt the Limb: Every 10th Minute being number'd and diſtinguiſh'd by a fine black Line painted croſs the Tube, and every five Minutes by Dots as uſual. The Tube is let into the Quadrant, about half way, and the other half is covered by a Piece of Wood, grooved in the ſame Manner as the Quadrant, and faſten'd to it by a pair of ſtrong Hinges. The Cover is made faſt by a Couple of Haſps at each End, and is deſign'd only to preſerve the Tube when not in Uſe. And thus the Quadrant is finiſhed and fit for Uſe; and is I think, in it ſelf ſo plain and ſimple, that after what has been already ſaid concerning it, it would be needleſs to trouble you with the Figure of it; eſpecially ſince any Perſon who has the Book, may be gratify'd with a Sight of the Inſtrument it ſelf at the Bookſellers.

And as the Uſe of it, is only to obtain the correct Zenith Diſtance of any Phenomenon, ſo the Method of gaining it, will be obvious to the meaneſt Capacity at firſt Sight. For in obſerving by the Sun, it is only holding the Quadrant perpendicular, ſo as the Bubble may be nearly in the Middle of the Tube; and

and then move the Ruler, till the Spot fall on the Center of the Croſs-lines; then place the Hair on the Limb exactly on that Degree to which it is neareſt. Then obſerving again, the Limb gives you the Degrees; and the End of the Bubble neareſt the Center, the Minute of the Zenith Diſtance.

But if you obſerve a Star, then turn aſide both the Braſs-Plates on the Sights, and hold the Quadrant in your Left-hand; and placing the End of the Ruler between your Fore-finger and Thumb, move your Right-hand ſo placed to your Eye; your Finger on the upper and your Thumb on your lower Eye-bone; by which means your Eye may be eaſily brought to be exactly in the Center of the Eye-glaſs. Turn then to the Object you would obſerve, and you will very readily ſee it greatly illuminated: Keep then your Eye on the Object, and move the Ruler at the ſame time on the Limb, till the Bubble be nearly in the Middle of the Tube. Then place the Ruler (as before) on that Degree to which it is neareſt. Then look again, and bringing the Object between the two perpendicular Hairs; cut it with the Horizontal one, and then any By-ſtander will obſerve the Bubble (as before) to ſettle at the exact Minute of its Zenith Diſtance; and the Degree is given by the Ruler.

Thus you may keep obſerving as long as you think fit; and if the Object be riſing,

the Bubble will give leſs and leſs Zenith Diſtance every time, till perhaps at laſt it goes back to no Degrees: If ſo, fix your Ruler to one Degree leſs, and obſerving as before, your Bubble will then give 60 Minutes more; and if the Object ſtill continue to riſe, it will ſtill give leſs and leſs, and at laſt its correct Meridian Zenith Diſtance, which you will plainly perceive by the Bubble's retiring back again, and increaſing its Zenith Diſtance; the leaſt being always the true Meridian Zenith Diſtance.

On the contrary, if you obſerve any Phænomenon that is ſetting, it may poſſibly happen that you may delay the Obſervation of the Bubble, till it is too near the Limb to be certain of the Truth: In this caſe, fix the Ruler to one Degree *more*, and the Bubble will then return when your Eye is on the Object to the beginning of the Minutes, and always give you the juſt Zenith Diſtance by *Inſpection only*.

The Teleſcope being only of two Glaſſes, the Object will be always inverted, ſo that an Obſerver who is not accuſtomed to it, when he ſees a Star ſeemingly above the Horizontal Line, will then elevate his Inſtrument ſtill more, according to the common Method; but the Object being inverted, tho' it appears above, yet it is really below the Horizontal Line; and the Obſerver muſt therefore depreſs his Teleſcope in order

to

to bring the Object down to the Line, which is a *Deceptio Visûs*, that a very little Practice will easily overcome.

To this Quadrant belongs a small Lanthorn to burn a Wax-Candle in; which is so contrived as to cast a Light, in time of Observation on the Tube only; and is hung on the Cover of the Tube when open'd, by two Hooks; the Observer holding the Instrument, Lanthorn and all, by which any Bystander may readily see the Settlement of the Bubble.

If any should have occasion for a Quadrant of a larger or smaller Radius than this, I would only leave the following Directions with the Workman.

As first, that the Degrees on the Limb be accurately divided, and if instead of the Hair he would fix a small Brass or Steel Index on the under Side of the Ruler, this might be better and sooner placed to the Division on the Limb, the Hair occasioning some Diffidence, by entirely covering it.

The Tube should be made of the finest and softest Metal; the Bore about four or five Tenths of an Inch in Diameter; and Care taken that in the Blowing of it, the Metal be of such a due Heat, as not to fall to too great a Curvature; and that the Blowers as they draw it out between two of them, do not move their Hands either up or down, especially at the time of its Forming; for that

that ſuch an Attempt to mend a ſeeming Fault in one Part would certainly ſpoil the whole Tube. Gravity alone with a ſufficient Extenſion will give it the moſt perfect Form, as I have often experienced. It is moſt convenient that the Bore of the Tube ſhould incline to an oval Form, the Flat uppermoſt; but this can hardly be attained in the common Way of drawing them, unleſs by Accident: I would therefore adviſe to make a long, thin, and every way equal Braſs-Ruler; which ſupported at each End, would of it ſelf fall to a curious Curve, the leſs the better; and being fixed on a Piece of Wood, and ſupported artfully in ſundry Parts of the Ruler, might ſerve as a Mould, on which to lay the glowing Tube: which by its own Gravity will ſink it ſelf into a proper Form.

The Tube form'd and neal'd, let the Workman try the Run of a ſmall Bubble every five or ten Minutes throughout the whole Piece, by which he will eaſily ſee what Part of the Tube will be fitteſt for his Purpoſe. If he deſigns his Inſtrument for Sea, he muſt have at leaſt 90 Minutes on his Tube, beſides the Bubble, and Room for Sealing, allowing about half an Inch at each End for that Purpoſe; that the Perſon who Seals them may have Subſtance enough to work on. Let the Bubble be as ſmall, and the Ends Seal'd as thick and as ſtrong as poſſible.

The marking of the Minutes on the Tube, I have already given Directions for; but if the Workman like not my Method, he may easily in the same Manner, by a Table of natural Sines and Tangents, form the Minutes of three or four Degrees, to a Radius of ten or twelve Feet, only to mark his Tube correctly by: and having marked one, he may by that, as a Standard, afterwards mark as many as he pleases; by laying the Pattern, and the Tube he would mark, both on the same Plane, and so raising them by a small Screw contrived for that purpose.

Having mark'd his Tube, let him set off 60 Minutes in the Middle, for the Minutes of his Zenith Distance, leaving an equal Remainder at each End exclusive of the 60, and moreover Room for the Bubble also, next the Limb: After which, let him so fix it in his Groove, as before directed, that when the upper Radius is Horizontal, and consequently the other exactly Perpendicular; the End of the Bubble nearest the Center may then rest exactly at the Beginning of the Minutes of his Zenith Distance.

When he first places his Tube on his Plane for marking the Minutes, if he then draws a fine Line on his Tube exactly through the Middle of his Bubble, he may, by that Mark, easily know when the Convex Side of his Tube is uppermost; and exactly in the same

Position

Poſition in his Groove, as when he firſt mark'd it on his Plane.

The Eye-glaſs muſt always be as large as poſſible, becauſe (the Object-glaſs being the ſame) the Field of the Teleſcope depends entirely upon it: For the larger the Diameter of this Glaſs is, the more of the Object is ſeen at once. And it is neceſſary that a Teleſcope for this uſe at Sea, ſhould take in a very large Compaſs; five or ſix Degrees at leaſt, otherwiſe the Obſerver will ſoon loſe the Object: Whereas when the Field is large, tho' the Ship be in a good deal of Motion, yet the Object will hardly ever move quite out of it. And ſo the Obſerver keeping always a Sight of it, may eaſily bring it to his Horizontal Hair again. The Eye-glaſs of my Quadrant is an Inch and an half in Diameter; and takes in juſt five Degrees with an Object-glaſs of about one Foot Radius; but I think it would have been much better full two Inches.

Such a Glaſs in Terreſtial Teleſcopes would indeed diſtort the Object, and ſpoil the Perfection of the Viſion; but all that is wanted in our Quadrant is to keep the Object always in View: We have only to obſerve one ſingle Point, and it matters not what Diſproportion other Objects may ſeem to have with it. The Ledge which the Eye-glaſs reſts upon, muſt therefore be as ſmall as poſſible.

If it ſhall be found neceſſary ſtill to enlarge the Field of this Teleſcope for Sea

Uſes,

Uſes, there is another Way of doing it, the *Eye-Glaſs* being ſtill the ſame; and that is by ſhortning the Focus of your Object-Glaſs; for as my Object-Glaſs is about one Foot Focus, and my Eye-Glaſs an Inch and an half in Diameter, and takes in a Compaſs of about five Degrees; ſo I find, by Experience, that the ſame Eye-Glaſs uſed with an Object-Glaſs of half the Length, will nearly double the Field. Whereas, if I uſe an Object-Glaſs of two Feet, or double that of mine, then the Field will be diminiſhed to about two Degrees and an half, being but the Half of what it now gives. So that the Field of your Teleſcope depends jointly on the Diameter of the Eye-Glaſs, and the Length of the Object-Glaſs.

Having finiſh'd the Vane of your Eye-Glaſs, it muſt be placed at the Diſtance of a little more than the Length of its Focus from the End of the Ruler, ſo that your Eye being in the Center of its Focus, may take in the Whole of the Field.

The Object-Glaſs ſhould alſo be of a pretty large Diameter; becauſe on this depends the Illumination or Brightneſs of the Object you view. And tho' by this Means the Object be ſomewhat diſcolour'd, (which is wholly improper in a Terreſtrial Teleſcope) yet it is not the Colour, but the Altitude of the Object that we are ſeeking: And certainly it will be beſt diſcern'd when moſt illumi-

 nated.

nated. It is true there needs no Art to encreaſe the Splendour of the Sun, unleſs when cloudy: And therefore when you obſerve the Spot of his Image, you had beſt to cover the Object-Glaſs, by a Braſs Plate, as before deſcribed; leaving only a ſmall Aperture in the Center of about two Tenths of an Inch diameter. And the Cover had beſt be on that Side of the Sight neareſt the Center of your Quadrant, to preſerve it from Duſt or any Accident.

Your Object-Glaſs muſt be truly center'd, otherwiſe your Inſtrument will be faulty, as is ſometimes more eſpecially the Caſe of the *Davis*'s Quadrant. I ſhall therefore here lay down a Method of centering them; which is this.

Place your Glaſs on a black Paper whereon is a white Speck; then, with your Face towards the Light, hold the Glaſs perpendicular to one Eye, which you will know when you ſee the faint Image of your Eye in the Middle of the Glaſs. Keeping the Glaſs thus, move a Pin's Head about two Inches before, and between the Glaſs and your Eye, and you'll then ſee two faint Images of the Pin's Head in the Glaſs; move the Pin ſo as that the Heads of both Images may coincide in one; and to that very Place of the Glaſs, move the white Speck on the Back of the Glaſs; and try it again, and if the white Speck, and the two Images of the Pin's Head, all coincide juſt under the Image

of

of your Eye, or juſt over the Pin which you hold in your Hand, then the white Speck is rightly placed, and the Part of the Glaſs over it is the true Center of the Glaſs; which mark with Ink, and then cut the Glaſs to your Diameter; by paſting the Center of a Paper-Circle truly drawn, upon the black Speck, and clipping your Glaſs to it; and thus you may examine any Object-Glaſs whatever.

The Quadrant thus finiſhed may be uſed at Sea in the Manner of an Aſtrolabe, by hanging it on the Finger only, which will very readily poize it ſo as that you may eaſily bring the Sun's Image to its proper Place, ſecuring the Inſtrument from falling, by tying a String to it, and ſlipping the Nooſe over your Wriſt.

Or by hanging it on a Shrowd, or any other convenient Thing, both your Hands would be at liberty nicely to adjuſt the Sun's Image, whilſt a By-ſtander obſerves the Settlement of the Bubble; for I would not have the Perſon who holds the Inſtrument attend to any Thing elſe but the Spot.

Or, if needful, the Inſtrument it ſelf may be hung on Gimbols, as the Compaſs is, ſo that the Tube may be always nearly Horizontal: And as the Sun is riſing the Inſtrument may be ſo balanced, by dropping ſmall Shot in a Veſſel placed for that Purpoſe, as gradually to raiſe the Tube in Proportion as the Sun advances in Height.

But without any of theſe Contrivances, a ſkilful Obſerver, by holding the Inſtrument in his Hand only, may eaſily take a juſt Obſervation; for the Error in the Zenith Diſtance, as the Quadrant declines Sidewiſe, either Way from the Perpendicular, increaſes only in Proportion to a Line of Sines from 90°. So that tho' an Obſerver ſhould deviate full two Degrees from the Perpendicular, yet his Zenith Diſtance, in this Caſe, would be but a very little more than two Minutes greater than it ſhould be.

And for an Obſervation by Night from the Stars, there needs no ſuch Contrivance, it being a very eaſy Matter to judge by the croſs Hairs when the Inſtrument is perfectly upright; for we are ſo accuſtomed either to the Level, or the Perpendicular, when we look ſtreight forwards, that it is almoſt impoſſible we ſhould judge amiſs.

I am very ſenſible that ſome People will be ready enough to object againſt this Inſtrument at firſt Sight, upon Account of the ſeeming unſteady Motion of the Bubble. But thoſe who are Judges of ſuch Affairs, will eaſily agree, that the ready Obedience of that Fluctuation, to every little Motion of the Inſtrument, is the neceſſary Conſequence of its great Accuracy. For if the Object be ſtable and conſtant, and the Inſtrument exactly directed to it, you will ſoon find the Bubble to fix accordingly; Tho', for the

ſteady

ſteady Direction of it, there is ſome little Skill required, which, as in moſt other Caſes, is only attainable by Practice.

Let it be conſidered, that the great Arch of this Inſtrument is in Proportion really 14 Times larger than that of a common *Davis*'s Quadrant; and that therefore the Deviations, tho' ſeemingly great, become ſo only as they are, as it were, magnify'd to the Eye. The Error is not the leſs in the common Quadrants, tho' it be leſs perceptible on Account of the Smallneſs of the Radius. Let any therefore judge which is the moſt preferable; that in which the leaſt Error is plainly diſcernable, or that by which a very great one is ſcarcely to be perceiv'd?

But ſurely ſome People love to be deceived; What elſe can be the Reaſon why many chooſe to obſerve by the Shadow-Vane, rather than by the Glaſs-Vane that caſts a Spot, but becauſe by the firſt the Error is partly hid, when by the laſt every Deviation from the Truth is too perceptible? And they chooſe the Shadow-Vane, becauſe when the Edge of the Shadow moves parallel to the Horizontal Line, on the Horizon-Vane, they can then only perceive the Perpendicular Deviation, and nothing at all of the Horizontal; unleſs they will take Care, at the ſame Time, to keep the End of the Shadow exactly on the croſs Line which anſwers to it, and which is placed there for that very

Pur-

Purpoſe. But this they will not do, for then it would be full as eaſy to obſerve by the Glaſs-Vane, and ſo they would loſe the Pleaſure, at leaſt, of thinking their Obſervation juſt, when it is, in this Caſe, almoſt always falſe. And thus the Inſtrument-Makers often ſuffer in their Reputation for Want of Skill in the Obſerver.

And now I am upon Errors give me leave to take Notice of another, which is really intolerable; and that is, the fooliſh Cuſtom of allowing no more than 42 Feet to a Knot upon the Log-Line; when it has been ſo long ſince proved beyond all Diſpute, by Mr. *Norwood* in *England*, and Monſ. *Picart* in *France*, by expreſs Order of the King, both agreeing, that the juſt Meaſure ought to be full 50 Feet; yet the old *Mumpſimus* is ſtill maintained, and that notwithſtanding the contrary is almoſt generally tho' tacitly acknowledged to be the Truth. What elſe can be the Reaſon why an Inſtrument-Maker is provided with ſhort half Minute-Glaſſes, as well as thoſe that are full 30 Seconds? And that if you aſk for one, his firſt Queſtion is, Whether you will have a long one, or a ſhort one? Doth not this naturally lead People into Errors? as it lately did an ingenious Friend of mine, who uſing a long Glaſs and the ſhort Meaſure, in a Voyage from *Antigua* towards *England*, being the firſt Time that he had the Command of a

Ship,

Ship, which for that very Reaſon he was the more circumſpect and careful in, being otherwiſe a very ingenious Artiſt; yet by this Means only he over-reckoned juſt ten Degrees. Which Miſtake had been entirely prevented, had he uſed the 50 Feet inſtead of the 42; for then his Reckoning would have been juſt out as he made the Land.

For knowing him to have been a very exact Man, I had the Curioſity to recalculate his whole Journal; and uſing his own Diſtances, with my Line of 50 Feet, I found the Difference, between the Land and my Account, no more than 18 Miles in the whole Voyage.

Is it not then a very great Diſcouragement to thoſe who may have any Thing of conſiderable Advantage to offer to the Publick, in the Practice of Navigation, when they ſee People thus ſtupidly wedded to ſenſeleſs and unreaſonable Cuſtoms; and that rather than they will part with an old Error, they will endeavour to mend it with a new one?

This obſtinate Proceeding of *Engliſh* Sailors, againſt Reaſon and Experience, is as great a Shame to the *Engliſh* Nation, as the pertinacious Humour of Drawing by the Horſe's Tail, for which they laugh at the old *Iriſh*. And it is ridiculous to fly for an Objection to the ſuppoſed Inaccuracy of the beforementioned Experiments, when it is notorious, that they were not only made with

with great Care and Caution ; but that the Event actually agrees with the repeated Experience of the Ingenious in their common Practice.

I would fain know whence the Cuſtom of allowing no more than 42 Feet firſt came. Who was the Author of it, or what Experiments were made to confirm it? For ſurely thoſe who make this Objection ought to produce ſome Experiments in Favour of their Cuſtom, made with greater Accuracy. Wherefore ſhould Navigation only, refuſe any Helps from actual Experience, when the learned World are daily making ſuch noble Advances in Natural Philoſophy, and all other Arts and Sciences are continually receiving ſuch great Improvements, from the laudable Method of building on that grand Foundation of Reaſon and Experience ?

But to return to my Inſtrument. Suppoſe then, that being in the Hand of a common Obſerver in a very grown Sea, it ſhould by any By-ſtander be obſerved to be ſeemingly uncertain, by the quick and nimble Traverſes of the Bubble; perhaps in this Caſe attempting to ſettle ſomewhere between 10 and 40 Minutes; yet the Truth will certainly be in the Middle between the contrary Attempts of each End, *viz.* 25 Minutes, as I have frequently experienced. For when I have purpoſely given my ſelf a reeling, unſteady Motion at the Time of my obſerving, ſo

ſo as that I have not been able to keep the Sun's Image any thing near its correſponding Spot on the Vane; yet only by a general Endeavour ſo to do, I have commonly found that the Middle, between the two Extreams of the Motion, hath given me the true Altitude of the Sun. But this is the worſt Caſe that can poſſibly happen, for at other Times you may expect the Truth, even to a very ſmall Matter, according to the Conveniency and Serenity of the Seaſon.

But there is another Objection againſt this Bubble; and that is, that it will not always keep of the ſame Length, but will vary perhaps three or four Tenths of an Inch, according to the Temperature of the Air. So that in hot Weather, by reaſon of its ſhortneſs, it will give *more*, and in Cold, *leſs* than the Truth, about *one Minute*. But as this is well known, ſo it may be eaſily corrected, by marking on the Tube, the Length of the Bubble when firſt adjuſted, and allowing for it, as it may afterwards be more or leſs than the Standard, at the Time of Obſervation.

CHAP. II.

Of an Obſervation for finding the Latitude *by the Sun, in Failure of a Meridian Altitude.*

THE Problem to find the Latitude by two Altitudes of the Sun and the Time between, hath been often publiſh'd; and the Method which almoſt every Author hath proceeded upon hath been this. Firſt, they find the great Circle's Diſtance between both Suns; and then the Angle formed by that, and the Sun's Diſtance from the Pole, at his loweſt Altitude; out of which they *ſubſtract* the Angle formed by the great Circle's Diſtance and the greateſt Zenith Diſtance; and then, with the *Remainder*, they proceed to find the Latitude: This Remainder being the Angle included between the Zenith Diſtance, and Pole's Diſtance of the Sun at his loweſt Altitude; the oppoſite Side to which is the Co-Latitude.

And indeed this Method is juſt in all Latitudes which *exceed* the Sun's greateſt Declination. But in North Latitude, if the Sun at his Meridian Altitude be in the North, or if in South Latitude he be in the South, *i. e.* if the Co-Latitude of the Place be greater than the Sun's Diſtance from the ſame Pole, then the ſecond Angle, inſtead of

of being ſubſtracted from, muſt be *added to* the firſt. And ſo the *Sum* will be the included Angle by which to find the Latitude, as before.

So that in doubtful Caſes, when the Sun is ſo very near the Zenith, that it cannot be aſcertained whether his Meridian Altitude be North or South, this Method is precarious: But when the Caſe is indiſputable, whether to ſubſtract or add, then the Problem is ſafe and uſeful. For tho' there be ſome Difference in the Pole's Diſtance between the two Obſervations, yet you may ſafely neglect it, it being moſtly ſo ſmall as not to breed any ſenſible Error.

The Deſign of this Problem is only to find the Latitude at Sea in Caſe of an Exigency, and for Want of other better Means. And becauſe the Ship may be ſuppos'd to be always in a progreſſive Motion, and to have alter'd her Place conſiderably in the Time between the two Obſervations; it is therefore neceſſary to add *another Caution*, which is; that there ſhould be always ſome Allowance made to the Time between, and to the greateſt Altitude, according to the Nature of the Courſe you have made. So that if the Ship, during the Time, hath made any conſiderable Eaſting or Weſting, the Difference of Longitude which that amounts to, muſt be added to or ſubſtracted from the given Time between, when reduced to De-

grees and Minutes, and the Sum if Eaſt, or the Difference if Weſt, will be the exact Time between; in Degrees and Minutes. And ſo many Minutes or Miles which the Ship hath run to the Southward, or the Northward, of her firſt Obſervation, muſt be alſo *added to*, or *ſubſtracted from*, the greateſt Altitude as taken; that is, ſuppoſing ſhe be in North Latitude, but the contrary in South. All which is only reducing both Obſervations to the Time and Place when and where the leaſt Altitude was taken.

As ſuppoſe I take my firſt Altitude in the Morning at the *Lizard*, in Latitude 50°. and ſailing then in three Hours exactly 19 Miles due Weſt (which in this Latitude is about ½ a Degree, or two Minutes in Time). I then take a ſecond greater Altitude. I am then to conſider what Altitude the Sun had juſt at that Moment at the *Lizard*, and as the *Lizard* now lies juſt two Minutes to the Eaſtward of me, ſo the Sun will have the ſame Altitude at the *Lizard*, as it had with me two Minutes before, or which is the ſame thing, and better for my Purpoſe, the Altitude at the *Lizard*, two Minutes before the three Hours, was juſt the ſame as it is now with me. If then I *ſubſtract* two Minutes from the three Hours, the Obſervations I have taken will be the ſame as tho' I had taken them both at the *Lizard*, at the Diſtance of two Hours 58 Mi-

Minutes ; but had I ſailed Eaſt, inſtead of Weſt, then for the ſame Reaſon I muſt have *added* the two Minutes to the three Hours ; becauſe the Altitude at the *Lizard* would *not* have been the ſame as with me, till two Minutes *after*.

In order therefore to reduce this to Practice, and becauſe it ſeldom happens that a Ship keeps always the ſame Parallel, I ſhall propoſe an Example, and ſhew how to find the true *Difference of Time*, and the *greateſt Altitude*.

Admit then that in the Morning there were juſt three Hours and ſix Minutes between each Obſervation, which is juſt 46 Degrees and 30 Minutes; and ſay that my Ship hath ſailed W. S. W. 18 Miles in that Time; and in the ſuppoſed Latitude of 51°. North, for a ſmall Matter here will not hurt much. Firſt then, I find my Difference of Latitude, and my Departure, and by that my Difference of Longitude. Saying,

		° '	Miles.
Rad. .. Diſt. 18 : :	S. c. Courſe	22. 30 ..	Diff. Lat. 6,8
	S. - Courſe	67. 30 ..	Depart. 16,6 which

in Latitude 51 gives 26' Dif. Long. which
ſub. (being W.) from the Time in Deg. 46 : 30

remains 46 : 4 the juſt Diff. of Time between the 2 Altitudes.

And then the laſt (and now the greateſt) Altitude would have been the ſame as obſerv'd, had the Ship continued in the ſame Parallel of

of Latitude ; but as by the Proportion above ſhe is gone about 6' further South, ſo the Altitude (being almoſt always taken when near the Meridian) of Conſequence is 6' greater than it would have been, had it been taken at the firſt Place. Deduct therefore ſix Minutes from the laſt Altitude (always rather * leſs than more) and the Remainder will be the ſame as tho' both had been taken at the firſt Place. But had the Ship ſailed 6' further *North*, you muſt then have *added it* to the laſt Altitude ; becauſe then it would have been 6' *leſs* than it ſhould have been. The Reaſon of all which is ſo plain, that it is needleſs to ſhew wherefore the Contrary will happen in South Latitude.

But becauſe it is the *Zenith Diſtances* which you calculate with, and which indeed your Quadrant always gives, I ſhall therefore put down the Rule how you are to add or ſubſtract the Difference of Latitude, to or from the leaſt *Zenith Diſtance*, in order to find the leaſt Zenith Diſtance to work by.

In	North Lat. and	North	Courſe ſubſt.	the Difference of Latitude to or from the leaſt Zenith Diſtance.
	South ———	South		
	North ———	South	Courſe add	
	South ———	North		

So

* *Note*, This is ſufficient for Practice, unleſs the greateſt Altitude be taken at any conſiderable Diſtance from the Meridian, and then it will be convenient to uſe the following Analogy. As s. of the ſuppoſed Meridian Altitude, is to the Difference of Latitude the Ship hath made ; ſo is the s. of the greateſt Altitude, to the Difference of Latitude to be allow'd.

So that if the Latitude be increaſing you muſt ſubſtract, but if decreaſing you muſt always add.

And to find the Difference of Time between each Obſervation, firſt, put down your whole Time in Degrees and Minutes; and then,

If your Courſe be	Eaſt, add / Weſt, ſubſtr.	the Difference of Longitude to or from it.

And the Sum or Difference you may proceed to calculate with.

And tho' this may ſeem a very difficult and tedious Calculation, eſpecially as cumber'd with the Cautions and Rules here lay'd down concerning it; yet the Truth abſolutely requires them: And as there may be a Time when other Methods of finding the Latitude may all fail; ſo it is highly neceſſary that all Commanders ſhould be acquainted with this.

And tho', for my own Part, I ſhould chooſe rather to obſerve by the Stars, for Reaſons I ſhall hereafter mention ; yet becauſe there are ſome who are ſo entirely wedded to an Obſervation by the Sun, as to be altogether unprovided with Inſtruments proper for the Stars, I have thought proper to free this Problem from the Errors it before was liable to, leſt the preſent Grand Requiſite in the Art of Navigation, ſhould too often fail for Want of a Meridian Altitude.

To

To encourage therefore ſuch as are willing to be at a little Pains, for the Safety of Ship and Cargo, I ſhall here propoſe a Scheme, which with the Directions given concerning it, will greatly ſhorten and facilitate the Work of this Problem; ſo that any Perſon, who is competently acquainted with the Method of working a Proportion by Logarithms, may by it readily find his Latitude in leſs than half an Hour's Time. Firſt then, let the following Scheme, and the ſeveral Proportions with it, be fairly written on a Piece of very thick Paper, and that exactly as it is here printed; after which cut out all the Figures of the Logarithms, and Sines, in Squares, as marked.

The Scheme being thus prepared, and the Figures in the Squares all cut out, as directed, keep the Paper always by you, and whenever you have Occaſion to find your Latitude by it, you will have no more to do than to fill up the Blanks, for which Purpoſe the Directions in the Scheme it ſelf are very ſufficient.

But to make all clear, I ſhall a little explain the Method of Procedure in the adjoining Scheme.

Being then upon a W. S. W. Courſe, in the ſuppoſed Latitude of 51°, and having by me a good Watch and Quadrant, I take my firſt Zenith Diſtance 57°, 10', and the Perſon who holds the Watch obſerves the

Time

The Scheme for finding the Latitude by two Observations of the Sun.

Rad. ·· Diſtance | Miles : : { S. / S. c. | ·· Departure - - - - Gives Diff. Long. / ·· Diff. Lat. - - - - - | in ſuppoſed Latitude
Sub. from Time if *Weſt*; if *Decreaſing*, *Add* to the *Leaſt Zenith Diſtance.*

h. m. "

Time of 1ſt. Obſ. - - - *Zenith Diſtance* -
Co.
2d Obſ.

Place the Deg. in theſe Proportions. | Logarithms.

× Hours by 15
Gives Degrees
Gives Deg.
Gives Min.
Gives Min.
Sum in Deg. and Min.
Whole time in Deg.

And divide the Min. by 4
And Remainder of Min. × by 15
And the Seconds divide by 4

Diff. Longitude as above

Requiſites

Sun's Diſtance - -	1ſt and 4th	1ſt and 2d
Whole Time - -	2d	
½ Time - - -	1ſt	
Greateſt Zen. Diſt.	2ce in 3d	3d, 4th, 5th
Leaſt Z. D. - - -	3d	

Proportion Iſt.

As Radius
To S. Sun's Diſtance - - -
So S. ½ Time - - - -
To S. ½ the 1ſt Sine doubled - - -
gives 1ſt Sine which place 2ce in the 3d Proportion

IId.

S. 1ſt Sine — Co. Ar. — Place this the 1ſt of the 3d
S. Whole Time - - - -
S. Sun's Diſtance - - - -
S. 2*d Sine* - - - - -

IIId.

add { 1ſt Sine / Great Z. D. / Leaſt Z. D. }
- - - - - - - - - - Co-Ar. S.
- - - - - - - - - - Co-Ar. S.

½ Sum -
Sub. 1ſt Sine -

½ Sum
Gr Z. D. *ſub.*
- - - - - - S.
- - - - - - - - - - - - - S.

add

Doubled — The ½

Leaves — Is the 3d Sine, which *Sub.* from the 2d Sine above.
The included Angle

IVth.

Radius
S. c. included Angle - - - - -
T. Great Z. D. - - - - - -
T. 4th Arch

Is T. — Sun's Diſtance which *ſub.*

Leaves the Reſidual Arch

Vth.

S. c. 4th Arch - - — - - - Co-Ar.
S. c. Reſidual - - - — - - - - - - - -
S. c. Great Z. D. - — - - - - - - - -
S. Latitude - - - — - - - - - - - -

This Table to face Page 33.

The Scheme for finding the Latitude by two Obſervations of the Sun.

Rad. ·· Diſtance 18	W S W Miles : :	S.	67 : 30	·· Departure - - - -	17	in ſuppoſed Latitude 51 n
				Gives Diff. Long.	26	*Sub.* from Time if *Weſt*;
		S. c.	22 : 30	·· Diff. Lat. - - - - - -	6	if *Decreaſing*, *Add* to the
					48 : 23	*Leaſt Zenith Diſtance.*
					48 : 29	

	h. m. "		
Time of 1ſt. Obſ.	9 : 4 : 0	M	- - - *Zenith Diſtance* - 57 : 10
Co.	2 : 56 :		
2d Obſ.	1 : 1 : 45	A	
	3 : 57 : 45		

Place the Deg. in theſe Proportions.

Logarithms.

× Hours by —	15	
Gives Degrees	45 : 0	And divide the Min. by 4
Gives	14 :	And Remainder of Min. × by 15
Gives Min.	: 15	And the Seconds divide by 4
Gives	: 11	
[...]m in Deg. and Min.	59 : 26	
Sub.	: 26	Diff. Longitude as above
[W]hole time in Deg.	59 : 0	

Requiſites	° '		
Sun's Diſtance - -	84 · 39	1ſt and 4th	1ſt and 2d
Whole Time - -	59 : 0	2d	
$\frac{1}{2}$ Time - - -	29 : 30	1ſt	
Greateſt Zen. Diſt.	57 : 10	2ce in 3d	3d, 4th, 5th
Leaſt Z. D. - - -	48 : 29	3d	

	As Radius			
Proportion Iſt.	To S. Sun's Diſtance	84 : 39	- - -	9,998104
	So S. $\frac{1}{2}$ Time - -	29 : 30	- - -	9,692339
	To S. $\frac{1}{2}$ the 1ſt Sine	29 : 22	- - -	9,690543
	doubled	29 : 22		
	gives	58 : 44	1ſt Sine which place 2ce in the 3d Proportion	

IId.	S. 1ſt Sine		Co. Ar.	,068155	Place this the 1ſt of the 3d
	S. Whole Time	59 : —	- - - -	9,933066	
	S. Sun's Diſtance		- - - -	9,998104	
	S. 2d *Sine* - -	86 : 48$\frac{1}{2}$	- - - -	9,999325	

IIId.

add 1ſt Sine	58 : 44	- - - - - - - - - - Co-Ar. S.	,068155	*add*
Great Z. D.	57 : 10	- - - - - - - - - - Co-Ar. S.	,075591	
Leaſt Z. D.	48 : 29			
	164 : 23	82 : 11$\frac{1}{2}$ $\frac{1}{2}$ Sum		
$\frac{1}{2}$ Sum -	82 : 11$\frac{1}{2}$	57 : 10 Gr Z. D. *ſub.*		
Sub. 1ſt Sine -	58 : 44	25 : 1$\frac{1}{2}$ - - - - - - S.	9,626350	
	23 : 27$\frac{1}{2}$	- - - - - - - - - - - - - S.	9,599970	
			19,370066	
	28 : 57$\frac{1}{4}$	The $\frac{1}{2}$	9,685033	
Doubled	28 : 57$\frac{1}{4}$			
	57 : 54$\frac{1}{2}$	Is the 3d Sine, which *Sub.* from the 2d Sine above.		
Leaves	28 : 54	The included Angle		

	Radius						
IVth.	S. c. included Angle -	28 : 54	- - - -	9,942239			
	T. Great Z. D. - - -	57 : 10	- - - -	10,190252		84 : 39	Sun's Diſtance
	T. 4th Arch			10,132491	Is T.	53 : 36	which *ſub.*
				Leaves the Reſidual Arch		31 : 3	

Vth.	S. c. 4th Arch - -	53 : 36	- - - Co-Ar.	,226639
	S. c. Reſidual - - -	31 : 3	- - - - - - - -	9,932838
	S. c. Great Z. D. -	57 : 10	- - - - - - - -	9,734157
	S. Latitude - - -	51 : 31	- - - - - - - - -	9,893634

This Table to face Page 33.

Time exactly four Minutes paſt Nine in the Morning: Having then fixt my Scheme upon a fair Paper or Slate, I put down 9 Hours, 4 Minutes, and M. for Morning againſt the Time; and 57°, 10' againſt the Zenith Diſtance of my firſt Obſervation; which done, my firſtObſervation is finiſh'd, and I muſt wait ſome two, three or four Hours, till I can again have a convenient View of the Sun for my ſecond Obſervation: And here I ſhall ſtop to make a few Remarks.

As firſt, that it will be convenient when the Weather is uncertain, always to take a Morning Obſervation by Way of Proviſo, leſt your Meridian Altitude ſhould fail you; but yet not too ſoon in the Morning, leſt the then great Refractions ſhould ſpoil the Obſervation: And alſo becauſe your greateſt Zenith Diſtance ſhould always be leſs than the Sun's Diſtance from the Pole, otherwiſe the two laſt Proportions, as by this Scheme, will not anſwer. Indeed the great Zenith's Diſtance will almoſt always fall out leſs than the Sun's Diſtance; but if Neceſſity ſhould oblige you to take it greater; then obſerve that inſtead of the Tangent and the Sine Complement of the great Zenith Diſtance in the fourth and fifth Proportions; you muſt uſe the Tangent, and S,c. of the Sun's Diſtance: And inſtead of ſubſtracting the fourth Arch from the Sun's Diſtance in the 4th Proportion, you muſt ſubſtract it from

F the

the great Zenith's Diſtance, and your Calculation will then be all right. But this Exception very rarely happens to the Rule or Scheme, which it was very convenient to make general; but whenever it doth, then the Vacancies of four Logarithms may all be taken out of one Page, *viz.* that of the Sun's Diſtance.

As to the Sun's Diſtance from the Pole, which is one of your Requiſites, I ſuppoſe it is needleſs to ſhew how to find it: Seeing all who have the Charge of Ships, either are, or ſhould be, perfectly acquainted with it, as the beſt Means for finding the Variation of the Compaſs: But leſt any ſhould be ignorant of it, I ſhall here let them know that the Pole's Diſtance, either of Sun or Star, is no more than the Complement of the Declination, when the Latitude and the Declination are both alike, North or South; but when *contrary*, the one North and the other South, then it is the Declination *added* to 90°. Thus you may know that this Obſervation was made on the 29th of *Auguſt*, 1730, it being taken in North Latitude, and the Declination then North alſo, 5°, 21' as the Complement of it, is exactly the Sun's Diſtance 84°, 39'.

I would alſo remark that the Exactneſs of any Obſervation, as well that by a Meridian Altitude, as this, depends very much on the adjuſting the Declination of your

Tables

Tables to the Meridian of your Ship, whether easterly or westerly from the Meridian of *London*; otherwise you may possibly in some Places, and at some Times, have an Error of 24 Minutes in your Latitude, tho' your Observation be ever so true, as hath been largely shewn by others.

And I add also, that by this Scheme, the Curious should have Respect to the Morning or the Evening; as the Declination (to instance when it is increasing) will then be less in the Morning, and more in the Evening than by the Tables; and that, according to the daily Difference of Declination. All that I can say is, that if Men will use Reason they may expect Truth, otherwise they must err, as well in the common Method as by this; tho' this I do assert, that if equal Care be had in both, this is as correct a Method as by the Meridian Altitude.

But it is now high Time to return to our Observation: Having therefore found my Sun's Distance, and adjusted it 84°, 39', I put it down among my Requisites; as also my supposed Latitude 51, and my Course W.S.W. or 67°, 30', and its Complement 22°, 30', each in their respective Blanks.

And now taking a convenient Time for observing a second Zenith Distance, I find it to be exactly 48°, 22', and my Companion at that Moment observes my Watch exactly one Minute, and about 45 Seconds after One.

And if this was a good Obſervation, 'tis well; but if it had not, I ſhould however have put it down by itſelf, but ſtill have waited, if poſſibly I might have gotten another more to be depended on; but having gained a good one, I immediately ſet it down in my Blanks, the Time 1^h, $1'$, $45''$ againſt the ſecond Obſervation; and the Zenith Diſtance $48°$, $22'$, being the leaſt, under the Difference of Latitude, that being to be added to it when found. I then retire to my Cabin and ſit down to work; and finding that I have ran 18 Miles ſince my firſt Obſervation, I ſet that down in my Blank Diſtance; and by the Proportion * I find my Departure 17, and my Difference of Latitude 6 (always taking it rather leſs than greater) which I accordingly put down. My Departure 17, in Latitude 51, gives me 26 Difference of Longitude; which being Weſt, according to the Rule, I ſubſtract from my Time when found. Then as the Latitude is decreaſing, I add my Difference of Latitude to my leaſt Zenith Diſtance as they ſtand; and the Sum is $48°$, $29'$ for my leaſt Zenith Diſtance to work by, which I alſo put down among my Requiſites; placing it againſt the greateſt or leaſt Zenith Diſtance as it proves, and my firſt Zenith Diſtance in the ſame Manner. I then look how the Blanks of my Time ſtand, and as the firſt Time was in the Morning, and the ſe- cond

* See Page 29.

cond in the Afternoon, I draw a Line under the firſt, and under that put down its Complement to 12 Hours being 1^h, $1'$, $45''$, which I add to the ſecond, and the Sum is three Hours 57 Minutes and 45 Seconds, which I multiply and divide as directed. Thus; the three Hours I multiply by 15, and it gives me 45 Degrees, which I put down: Then the Minutes being 57 divided by 4, give 14 Degrees more, and there remains one Minute, which multiply'd by 15 gives 15 Minutes: Then the Seconds being 45, I divide by 4, and it gives me 11 Minutes more, all which I put down ſeparately as in the Scheme, and the Total in Degrees $59°, 26'$, from which I ſubſtract the Difference of Longitude as directed; and the Difference of Time to work by is juſt $59°, 0'$, which I place among my Requiſites, and its $\frac{1}{2}$ alſo $29°, 30'$; and ſo I have all my Requiſites; and tho' this may ſeem tedious to deſcribe, yet in Practice you'll find it very eaſy: The Blanks always directing you at Sight what to do, and plainly ſhewing the Progreſs as you go on, without any Confuſion or Burthen to the Memory: The particular Rules when to add, and when to ſubſtract, being all ſpecify'd in the Scheme it ſelf, or the Contrary naturally inferr'd.

And thus having finiſh'd my Requiſites, it appears by my Scheme, that the next Thing I have to do, is to fill up the Degrees

grees of my Proportions, in order to work them; to which I am plainly directed by the first Column after the Requisites: The Figures against which, denote the Number of the Proportion, in which each Requisite is to be placed. Thus against the Sun's Distance you will find 1st and 4th, which signifies according to the Title, that I am to place the Sun's Distance being 84°, 39', in the Blanks of the *first* and the *fourth* Proportions, where the Word directs me. And tho' the Sun's Distance be also made use of in the second Proportion, yet it is needless to place it there: Because the Logarithm of it, is the same with that in the first Proportion, as I shall presently shew. And so proceed to dispose of the other Requisites in like Manner according to the Directions in the Column. Which done, the whole will be ready to calculate: For tho' you will find many other Blanks in your Scheme besides those for the Logarithms, yet the Directions in the next Column will sufficiently supply that seeming Defect.

Turn then to your Table of Logarithms, and finding the Sine of your Sun's Distance 84°, 39', place its Logarithm (being 9,998104, as directed in the second Column) in the first and second Proportions.

In like Manner turn to the Degree of your great Zenith Distance 57°, 10', out of which single Page you may fill up, as by your

your Column, the Logarithms of this Requi-ſite in your third, fourth and fifth Proportions: Only carefully obſerve to take the Comple-ment-Arithmeticals of its Sine, for the third Proportion; the Tangent for the fourth, and the Sine Complement for the fifth, as they are marked in each; all which a little Practice will make you very ready in. *

This done, you may begin to work your firſt Proportion, the Product of which being doubled, produces what I call the firſt Sine 58°, 44', which tho' uſed in the ſecond, you need not put down, it being plainly ſignified in the Scheme: Only follow the Direction that is againſt it, which is that you place it twice in the third Proportion: And tho' you may now forget to do it, yet when you come to work the third Proportion, you will ſoon ſee by the Blanks, that you will there twice have Occaſion for it.

I think it needleſs to proſecute this Matter any further; for if you will proceed according to the Directions in the Scheme, as you meet with them, you will certainly find the Latitude to be 51°, 31': This being an Obſervation actually taken in *London*, tho' I afterwards added the Proportions of the fictitious Run of the Ship, in order to make

* And here I would obſerve to you, that in every Page of the Logarithms (if you reject the Characteriſtick) the firſt and ſixth Columns, the ſecond and fifth, and the third and fourth, are alternately the Complement Arithmeticals to each other.

it

it uſeful at Sea, where it will almoſt always happen.

And now let no Man think it ſtrange, as ſome perhaps will be ready to do, that I ſhould propoſe a Problem of this Kind, and that only for the Diſcovery of the Latitude; when perhaps he may imagine that ſomething much leſs formidable and prolix might have ſerved for attaining his Longitude. Nor let any one be ſo unwiſe as to reſolve immediately to reject this Method of proceeding, upon Account of the Uncertainty or Trouble that he may imagine to be in the Calculation: But rather let it be conſidered, that even a common Meridian Altitude cannot be had at Sea, without ſpending a great deal of Time, and the being at the Trouble of making a great many Obſervations, Trials and Alterations, before you can be aſſured that the Sun is fallen; and that in the very Heat of all the Day; and perhaps as it may happen in very turbulent Weather; being always tied to one ſtated Time. So that after all, it but ſeldom happens that you can call it a good Obſervation; and when finiſhed, the finding your Declination, adjuſting it to your Meridian, adding or ſubſtracting it to or from your Zenith Diſtance, and the like, will altogether (Obſervation and Calculation) probably take up more Time as well as Trouble, than ever yet you have diſtinctly computed.

Whereas

Whereas all the Trouble that I have in my Way of obſerving is, only out of one whole Day to chuſe two the fitteſt and calmeſt Seaſons for each ſingle Obſervation, and to note the Time between. And as to the Time I will leave you to judge; for as this was the firſt, and indeed the only Time that ever I had obſerved by this Scheme, ſo I had a Mind to try what Time it might take to calculate it. And accordingly, laying my Watch all the Time by me, I fairly begun and finiſhed the whole Calculation, exactly in 31 Minutes. Now it cannot be ſuppoſed that I purpoſely deſigned to be herein more than ordinary expeditious; for it is well known, that any extraordinary Anxiety of that Kind never fails to put a Man beſides his Purpoſe. So that if I had *had* any Deſign that Way, it is certain that whenever it is performed in an ordinary and practical Way, that then it will be better and ſooner attained.

And then as to the Objection, with reſpect to the Uncertainty of it, I deſire you would only take Notice, that after having been very correct (which is very eaſy) in the Time between, that then the Correctneſs, in both Caſes, entirely depends on the Truth of the Zenith Diſtance. And I deſire to know which is moſt like to be the beſt, that which I am tyed to for Time, or that which I have my own Choice in. If any will yet

 object

object the Danger of erring in the Figures, *that* may easily be prevented, by two Persons performing the Operation their own Way, from the same *Data*, and checquing each other. And I know no Reason why the whole Ship's Company, that keep Journals, should not all depend upon one Operation for the Latitude, as well as for their Departure by one Tryal of the Log.

CHAP. III.

Of observing for the Latitude *by the Stars.*

IT would not perhaps be impossible to propose such Instruments, and lay down such Rules for the finding the apparent Place of the Moon, as might, by comparing it with her Place found by Calculation, be sufficient to the Curious and Industrious, for the finding the Longitude at Sea. But the reducing of it to a Method, sufficiently concise and expeditious for *common Practice*, is really a vain Attempt; since we find, by Experience, that many who use the Sea, are not to be persuaded to any extraordinary Pains: and therefore wholly decline any thing, that hath but the Appearance of a difficult or uncommon Calculation: Scarcely one in an Hundred (except in *India*

Voyages

Voyages) ever troubling themſelves with that neceſſary Requiſite in their Art, the Variation of the Compaſs; tho' it be ſo eaſily found, and ſo greatly uſeful. Any ſeeming Difficulty preſently diſcourages them, and therefore it is that they almoſt wholly decline the uſe of the Stars; eſteeming it more (tho' it be really leſs) difficult to obſerve by them than by the Sun. And tho' it be ſometimes abſolutely neceſſary, as appears by the frequent Complaints in their Journals, of the Sun's being too near their Zenith; or of the Sun's being overclouded at Noon: Yet of all the Journals that I have ever peruſed, I could never yet ſet Eye on any Obſervation taken from the Stars.

I would willingly hope, that it is chiefly owing to the Difficulty of doing it with the common Inſtruments; all of which depending on an Horizon, are thereby frequently rendred uſeleſs, thro' Fogs, Banks of Clouds, and falſe Horizons, which are very frequent at Sea, in the Night-time. But I think that Objection will by this Inſtrument be entirely remov'd, for that it will be nearly as eaſy to obſerve with it by Night as by Day. As therefore, there are ſo many Advantages will accrue to the Voyage, by an Obſervation from the Stars: So I hope for the Time to come, it will be more generally put in Practice.

The Places of almoſt all the Stars, are now thro' the Diligence and Induſtry of many of our great Aſtronomers, ſo perfectly ſettled by correct Obſervations, that their Declinations may be entirely depended on. The Ignorance of them would really be a Shame for any to plead, ſince it is ſo eaſily attained; eſpecially as far as the *1ſt* and *2d* Magnitude which will be moſt uſeful at Sea. The Conveniency and Frequency of one or other of them, being almoſt continually upon the Meridian, is an Argument that ſhould excite you to the Uſe of them: So that if at any Time of the Night, the Meridian only be but clear for a very ſmall Space, you may gain by them a true Latitude: Yea, if you can but for one ſingle Minute, diſcern any two known Stars, that ſhall, but as it were, juſt paſs between the raking Clouds, you may by their Altitudes only, find your Latitude.

A Thing of ſuch vaſt Conſequence in the Art of Navigation, that I dare affirm, many Ships, and Lives have been loſt for Want of it. How often doth it happen, that you are without the Sun for Weeks together? And how much more frequent is it, that the Sun is unexpectedly overcaſt by ſome ſudden Cloud, juſt at the Time when you ſhould gain your Meridian Altitude, and your deſired Latitude thereby entirely loſt? Whereas, as I have frequently obſerv'd, great Part of the

the ſucceeding Night hath been perfectly ſerene and clear. Conſider only the Neceſſity of finding your Latitude, when you are drawing near your Coaſt: The Time that is then often loſt for Want of it, and the Danger you are thereby particularly expoſed to. Conſider the Difficulty of taking an Obſervation when the Sun is ſo near your Zenith, that you are obliged to ſtand with a Compaſs between your Legs, in order to know whether the Sun be on the Meridian to the *North* or *South* of you. All which might often be eaſily remedy'd, by means of the Stars; for out of their Variety, you may at any Time chuſe ſuch as are then fit for your Purpoſe.

Beſides, their Declinations are almoſt always the ſame, ſome of them varying but a Trifle in an Age; whereas the Sun is continually changing his Declination, which makes it ſomewhat more difficult to calculate by it: There being an abſolute Neceſſity of having a due Regard not only to the Quantity, but alſo to the Quality of his Declination, whether *North* or *South*; as alſo to the Difference of Meridians, between that of your Ship, and the Place for which your Tables were calculated.

Further, the Right Aſcenſions of the Stars are all ready calculated, and in your Tables: So that you have the Difference of Time between one Stars coming on the Meridian, and

and that of another, ready given : By which *data*, as I have already hinted, and ſhall further ſhew, you may find your Latitude only by taking the Altitude of 2 known Stars at the ſame Time; and if I miſtake not, my Inſtrument will give them ſufficiently Correct. You may further conſider, that the Grand Problem for finding the Longitude at Sea, can never be ſolved without a competent Acquaintance with the Stars; and that *that* was one Occaſion of the founding the Royal Obſervatory at *Greenwich*, in order to ſettle their Places for that very End: 'Tis Pity therefore that you will not qualify your ſelves to partake of the Labours of the Learned, eſpecially when you may expect ſomething of that Kind will be ſhortly publiſh'd to the World.

The Method of obſerving by the Meridian Altitude of a Star, is exactly the ſame as by the Sun; only that the Declination of the Star is always the ſame, and therefore not ſo liable to Miſtake. But leſt any ſhould apprehend a *continued* Obſervation too troubleſome and tedious in the Night-time; I ſhall here propoſe ſome Methods of finding the Latitude by the Altitude of 2 known Stars, both taken at the ſame Moment of Time.

PRO-

PROBLEM I.

To find the Latitude, by the Zenith Distance of any two known Stars, being on the same Azimuth; or when one Star appears in a perpendicular Line over the other.

Suppose for Example, at any Time when A and B (so called for Distinction sake) are both found in the same Azimuth: I observe the Zenith Distance of A the highest 30° : 0'
B ———— 58 : 30

Then the Difference of their Z. D. will be the Distance of the 2 Stars. } 28 : 30

Turning then to my Tables, I find that
A's Right Ascension is 78° : 20' and its Pole's Distance 62 : 36
B's ———— 104 : 50 ———— 79 : 42

So that — 26 : 30 is the Difference of Right Asc.

1st. Then, say

As S. Distance of Stars —	28 : 30	Co-Ar.	,321337
To S. Diff. of R. Asc. —	26 : 30	———	9,649527
So S. Greatest Pole's Distance	79 : 42	———	9,992944
To S. included Angle —	66 : 56	———	9,963808

And the included Angle thus found is almost always *Acute*; but when the Angle composed by the Distance of the Stars, and the Pole's Distance of the highest Star, happen to be less than 90°; then the included Angle will be *Obtuse*, or more than 90°. And in this Case, the *4th* Arch, found by the next Proportion, must be *substracted* from

from the greater Side's Complement to 180°; and the Remainder will be the Refidual Arch. But this can very rarely happen, and may eafily be difcovered by a View of the Stars themfelves.

Then the two Sides which include this Angle, are the Zenith Diftance, and the Pole's Diftance of the higheft Star; and the Side oppofite to the included Angle, is the Co-Latitude of the Place.

Therefore 2*dly*.

As Radius.	°	
To S. c. included An.	66 : 56'—9,593067	
So T. LefferSide	30 : 0 —9,761439	
		62° : 36' great. Side
To T. 4th Arch	12 : 45 —9,354506	is 12 : 45 which fub.fr.
	Leaves the Refidual Arch	49 : 51

Then 3*dly*.

As S. c. 4th Arch —	12 : 45 —	Co-Ar.	,010843
To S. c. Refidual Arch	49 : 51	—	9,809419
So S. c. Leffer Side —	30 : 0	—	9,937531
To Sine Latitude —	34 : 56	—	9,757793

And here obferve, that the Triangle of the firft Proportion is compofed of the Pole's Diftance of each Star, and of their Diftance from each other: Which being always the fame, the Work might be greatly fhorten'd by previoufly calculating the Diftance of feveral chofen Stars, proper for that Purpofe; as alfo the included Angle and its Logarithm: Which being placed orderly in

a

a Table, together with their Poles Diſtance, the Obſerver need only take the Zenith Diſtance of the higheſt Star, whenever it is found in a proper Situation; and by the help of his Table, he may readily proceed to find his Latitude by the two laſt Proportions only.

But as in this Caſe, one ſhall be obliged to wait till the Stars ſhall be both found in the ſame Azimuth; and as my principal Deſign by theſe Problems is to furniſh you with the Latitude in Caſe of Exigency or Diſtreſs, that you may never want it, whenever you have but the leaſt Intermiſſion of cloudy hazy Weather; ſo I ſhall in the next Problem, propoſe to you a Method of finding your Latitude by the Stars, in the ſame Manner, as in the former Chapter I have done by the Sun: Only with this advantageous Difference, that as the Diſtances of the Stars are always the ſame, and their Pole's Diſtance alſo, for many Years; ſo to encourage you to this Method, I have eas'd you of half the Labour, by chooſing ſeveral convenient Stars, and Calculating the Diſtance of each Pair, which I have put down in a Table, together with the Co-Ars of the Log. Sines of their Diſtance; as alſo the Angle of Poſition formed by the Star's Diſtance, and Pole's Diſtance of the *loweſt* Star. By which Tables, and the following Problem, you may very

readily find the Latitude the Moment the Stars appear within View.

PROBLEM II.

To find the Latitude, by the Zenith Diſtance of two choſen Stars, and other Requiſites in the adjoining Tables.

RULE.

Add together the Star's Diſtance, and the two Zenith Diſtances; and from the Half of the Sum, ſubſtract ſeparately the Diſtance of Stars, and the greateſt Zenith Diſtance: Then to the Log. Sines of each Remainder, add the Co-Ars of the Sines of the Diſtance of Stars, and the greateſt Zenith Diſtance. The Half of theſe four Logarithms is the Log. of Half the Sine of an Angle, which therefore doubled, and *in moſt Caſes ſubſtracted* from the Angle of Poſition at the loweſt Star, as by Table, gives the included Angle: The containing Sides of which are the Zenith Diſtance, and the Pole's Diſtance of the loweſt (I ſay the loweſt) Star; with which two Sides, and the included Angle, you may proceed as by the laſt Problem to find the Latitude.

But becauſe in this Caſe, as by the Sun, if the Complement of the Latitude be greater than the Pole's Diſtance of the Star that is neareſt the Meridian, then the firſt Angle found, muſt be *added to* the Angle of

of Poſition at the loweſt Star: I have therefore added a particular Table of Southern Stars, to prevent any Uncertainty in Practice: And that the Rule might be General, always to ſubſtract as by the Scheme; only obſerving to uſe the *Particular* Table of *Northern* Stars, till you are in the Latitude of 20 Degrees North; and afterwards the Southern, till you are croſs the Line; and when paſt the Line, you may uſe the Northern Stars again; but then you muſt work by their Diſtances from the *South* Pole, as alſo by the Complements to 180 Degrees, of the Angles of Poſition, as by Table. So that to prevent Miſtakes, when you uſe the particular Table of Northern Stars, in South Latitude, you had beſt make a new Table of them; and inſtead of the Numbers in the two firſt Columns, put down their Complements to 180 Degrees.

And now to reduce this to Practice, and not to burthen your Memory with Rules and Cautions, I ſhall propoſe a Scheme for this alſo, in the ſame Manner as I did for the Sun: Wherein I ſhall lay the Work plainly before you, and in it, give ſuch Directions as ſhall be very ſufficient to perfect the Calculation.

And for an Example, I ſhall fill up the *Blanks* of the following Scheme with the Numbers of an Obſervation taken from the

1ſt Pair of Stars in the particular Northern Table, *viz.* The Tip of *Pegaſus*'s Wing, and Mandibula, Mandibula being the loweſt, and both in the *Eaſtern* Hemiſphere.

And herein the Method of Procedure is this.

Firſt, I put down the two Zenith Diſtances, as obſerved in the Blanks of the firſt Proportion; then I place the greateſt Zenith Diſtance in the 1*ſt*, 2*d*, and 3*d* Proportions againſt the Words, greateſt Z. D. as they ſtand in the Scheme; after which turning to the particular Table of *Northern* Stars, I find thoſe I have been obſerving; being in this Example the firſt Pair: And as Mandibula is the loweſt, ſo I poſt the ſeveral Numbers ſtanding againſt it, to the Blanks of each Proportion, as ſpecify'd at the Head of every Column, *viz.* 73° : 6' in the 1*ſt* Proportion; 86° : 59' in the 2*d*; 43° : 1' twice in the 1*ſt*, and 166086 being the Co. Log. of the Diſtance of Stars in the 1*ſt* Proportion; which done, I begin to calculate; and turning to the Logarithm of the greateſt Z. D. being 68° : 53'. I put down the Co. Ar. of its Sine in the 1*ſt* Proportion, *viz.* ,030189; (againſt which in the Scheme ſtands T. 2*d*; S. c. 3*d*; which ſignifies that I muſt put down the Tangent of the ſame in the 2*d*, and the Sine Complement of it in the 3*d* Proportion :) Then I put down the Logarithms of the two remaining Sines in the

Proportion I.

add Dist. of Stars	43 : 1	- - - - - - - - - - - - Co-Ar. S.		,166086	T. 2d, S. c. 3d.
add Greatest Z. d	68 : 53	1st, 2d, 3d, - - - Co-Ar. S.		,030189	add
add Least	40 : 16				
	152 : 10	76 : 5	½ Sum		
½ Sum	76 : 5	68 : 53	Gr. Z. d. sub.		
Sub. dist. of Stars	43 : 1	7 : 12	——— S.	9,098066	add
	33 : 4		——— S.	9,736886	add
				19,031227	
S.	19 : 8	- - - the ½ -		9,515613	
Doubled	19 : 8				
	38 : 16	which sub. from			
The Ang. of Position at lowest*	73 : 6				
Leaves the included Angle	34 : 50				

II.

Radius						
S. c. includ. Ang.	34 : 50	- - -	9,914246			
T. greatest Z. d.	68 : 53	- - -	9,413185		86 : 59	Pole's dist. lowest*
		T. 4th Arch	10,327431	is T.	64 : 48	which sub.
		Leaves the Residual		Arch	22 : 11	

III.

S. c. 4th Arch	64 : 48	- - - Co-Ar.	,370815
S. c. Residual	22 : 11	- - - -	9,966602
S. c. greatest Z. d.	68 : 53	- - - - -	9,556626
Sine Latitude	51 : 35	- - - -	9,894043

the 1*st* Proportion; then adding the Logarithms, I find the ½ to be 9,515613, which is the Log. Sine of 19° 8', which doubled and ſubſtracted from the Angle of Poſition at the loweſt Star, leaves the included Angle; and ſo proceeding gradually according to the Directions in the Scheme, I found the Latitude to be 51° : 35.' 'Tis needleſs to give more Examples; for, following theſe Directions, and obſerving by any other Pair in the Table, the Reſult would have been the ſame Thing: Only *take care always* to uſe the Numbers that ſtand againſt the *loweſt Star* in the 2 firſt Columns of the Table; together with the ſingle Numbers in the other Columns, which are common to both Stars in every Pair; ſo that had the Tip of *Pegaſus*'s Wing been the loweſt Star, I muſt then have uſed 100° 28' in the 1*ſt* Proportion, and 76° 18' in the Second; which would have been the Caſe, had the Stars been both in the *Weſtern*, as they were in the *Eaſtern* Hemiſphere at the Time of the Obſervation.

And now, tho' it be ſomewhat out of Place, yet I cannot forbear mentioning the following Article, which I accidentally met with upon taking up the *London Journal* of the 26th of *Dec.* laſt: Where it is ſaid, *That the* Expedition *Capt.* Leaper, *bound from* Leghorn *to* Hamburgh, *on the 9th Inſt. at one at Night, ſtruck three times on the* Cerns, *but beat off,* *and*

and ſoon after ſunk in 10 *Fath. Water, about* 4 *Leagues from the Coaſt of* Wales, *where the Crew got on Shore in their Boat the next Morning. They ſaw the Wrecks of* 2 Engliſh *Ships at the ſame time; and their Misfortune was owing to their not having made any Land ſince the* 15*th of* Nov. *when they left Cape* Spartel.

Now it may be very reaſonably ſuppoſed that theſe Ships periſhed for want of knowing the *proper Means* to find their Latitude; for tho' it is poſſible they might not have had any opportunity of obſerving for it by a Meridian Altitude, yet I dare affirm that there were not 3 Days together, in all the Month of *Dec.* in which I cou'd not have been able to have obſerved the Latitude, either by the Sun or Stars, by the Method here propoſed.

But to go on, you may here take Notice, that as by the Sun, ſo here alſo, the Rule is made general: Always ſuppoſing the greateſt Z. D. leſs than the Pole's Diſtance of the loweſt Star; which in this Caſe is very eaſy to do, having ſuch Choice of Stars; and indeed it is much better, that it be ſo, on account of the Refraction.

But if there be a Neceſſity of taking it greater, then the Poles's Diſtance of the loweſt Star, and the greateſt Z. D. muſt always be us'd contrary, in the ſame Manner, as by the Caution given in this Caſe by the Sun. But it is to be obſerved, that when the *Southern* Stars are uſed in *North* Latitude, or the *Northern*, in *South* Latitude, that

that then the greateſt Zenith Diſtance cannot poſſibly be taken otherwiſe than according to the Scheme: And therefore the Obſerver will then be out of all Danger of Error in that Reſpect.

There is only one Thing more, that I would put you in Mind of, which is, that if the Stars be both *riſing*, you ſhould then take the Zenith Diſtance of the *loweſt* firſt; and on the contrary when both are *ſetting*, begin with the *higheſt*; becauſe the ſmall Time that will neceſſarily be taken up in the 2*d* Obſervation, will very much thereby conduce to the rectifying the greater Refraction of the loweſt Star.

The particular Tables of the Stars are carefully calculated from the Places they will be in, about the Middle of *November* 1731. They are placed orderly in Pairs, as they will gradually and ſucceſſively appear above the Horizon. The ſecond Star of each Pair is the loweſt when in the *Eaſtern*, and the firſt, the loweſt, when in the *Weſtern* Hemiſphere. The firſt Column of Numbers, ſhews the Angle of Poſition at every Star, *when loweſt*; The Second, the Star's Diſtance from the *North* Pole; The Third, the Diſtance of the Stars from each other; All in Degrees, Minutes, and Seconds; And the fourth Column ſhews, the Co. Ar. of the Sine of the Diſtance of each Pair: And the Numbers at the Head of each Column

under the Title, denote the ſeveral Proportions in which they are to be placed in the Scheme; the Numbers before the Names of the Stars, only referring to the like Numbers in the general Catalogue.

Thus, by theſe Tables, and the foregoing Scheme, the Latitude may readily be found in any Part of the World, whenever the Stars appear within view, and that not only by my Inſtrument, but by any other now in Uſe for that Purpoſe: Theſe double Obſervations being herein ſingularly Advantageous; for if the Stars you obſerve, be both riſing, or both ſetting, any thing evenly in Proportion alike, tho' there might be ſome ſmall Error in the Horizon, or otherwiſe; yet the one Error will balance the other. For ſuppoſe you obſerve two Stars both at the ſame Time, and about a Quarter of an Hour after, when they are ſomewhat riſen, you obſerve them again, you will find that the Difference of their Altitudes at the firſt Obſervation, will ſcarcely differ any Thing from their Difference at the Second. And ſo if you calculate the Latitude, by the Obſervations of each Time ſeparately, you'll find they will both produce the ſame Latitude. So that had your Inſtrument by any Means erroneouſly given you nearly the ſame Altitudes at the 1*ſt* Obſervation, which it really did give you at the Second; yet you could not thereby have greatly erred in your

your Latitude, the one Error being proportionable to the other.

For my Part, I find the Advantage of this Method of obſerving ſo great, that tho' at firſt, I only deſign'd it in Failure of a Meridian Altitude, yet I now really think it preferable to it; eſpecially where there is occaſion to find either the Hour or the Azimuth at the ſame Time; becauſe having the included Angle given, I could by the ſame *Data* readily find both by this eaſy Proportion,

$$\text{S. c.Lat.} \cdot\cdot \text{ S. included Ang.} :: \left\{ \begin{array}{l} \text{S. greateſt Z. D.} \cdot\cdot \text{ S. Hour} \\ \left. \begin{array}{l} \text{S. Po. Diſt. loweſt *} \\ \quad \text{or by the Sun,} \\ \text{S. Sun's Diſtance.} \end{array} \right\} \cdot\cdot \text{ Azim.} \end{array} \right.$$

whether leſs or more than 90° might eaſily be judged by the Time and Seaſon.

But however advantageous this Method of obſerving by the Stars, may prove to thoſe who are acquainted with them, it will be entirely uſeleſs to thoſe who are ignorant of them. That nothing therefore might be wanting, in order to render this a complete Guide to the Knowledge of the Stars; I have here given a general Catalogue of all the principal Stars, with their right Aſcenſions and Declinations; as alſo a Table of the right Aſcenſion of the Sun for every Day of the Year. And at the End of the Book, I have added a Map of the *Northern* Stars projected on the Plane of the Equator, as alſo another of the Equinoctial Stars,

wherein the Stars are laid down on each Side of the Equinoctial, and thereby their Position one with another the better discerned; and in both I have put down all the principal Stars as they are commonly inserted in Books of Navigation: Tho' without the Figures or Names of the Constellations, to prevent Confusion: Only numbering them on the Edge of the Map, whereby they may easily be distinguished one from another; the Numbers in the Map referring to the same Numbers as they stand in the general Catalogue.

The Stars are chiefly of the *1st*, *2d*, or *3d* Magnitude, and the Numbers belonging to them are all placed without the Body of of the Maps, the better to preserve the Symmetry and Likeness of the general Appearance: The small Stars and other Points without Numbers, and adjoining to some of the principal Stars, being only inserted as they render those Stars more particularly remarkable. And tho' the principal Stars are *not* number'd in the Body of the Map, yet if you lay a Ruler on the Center, suppose of the *Northern* Map, and cause the Edge of it to cut any principal Star, the End of the Ruler will cut the Number of it in the Circumference; or if you fix a Thread to the Center; it will, when extended, equally cut any Star and the Number belonging to it. Where the Thread cuts two principal Stars, you

you will find two Numbers in the Margin anſwering to them, the Number neareſt the Center anſwering to the *Star*, that is neareſt the Center.

In like Manner, the Numbers of the principal Stars in the *Equinoctial* Map, may be readily found, by laying a Piece of Paper folded exactly in the Manner of a Square. One Edge of the Square on the middle Line, which anſwers to the Equator; and then the other Edge of the Square will cut any Star, and the Number belonging to it, on the outſide Edge of the Map. And where there are double Numbers, they are placed in the ſame Order with the Stars belonging to them; that Number that is *neareſt* the Equinoctial, belonging to that *Star* that is alſo neareſt the Equinoctial. The Numbers on the Top, or *North* Part of the Map belonging to the *Northern* Stars; thoſe on the Bottom or *South*, to the Stars that are on the *South* Side of the Equinoctial. But without uſing either a Thread or a Square, I apprehend it will be very eaſy to diſcern the Number that belongs to any particular Star.

And where there is a Figure of o in the Margin, it ſignifies, that the Star in the Map that belongs to it, is *not* in the general Catalogue, ſuch Stars being placed in the Map, only to give it a general Likeneſs with the Heavens.

They

They are all laid down contrary to the common Method which repreſents the *Convex* of the Globe: Whereas this repreſents the *Concave*; and is exactly the very Picture of the Heavens. So that any Perſon who holds, for Inſtance, the *Northern* Map before him, and looks towards the *North*, will ſee the ſame Stars in the Heavens, which are repreſented in the Map, and that in the ſame Order, and without any Confuſion.

In like Manner holding the Equinoctial Map, in the Manner hereafter repreſented, and looking towards the *South* in *North Latitude*, the Perſon will then ſee all the principal Stars that are near the Equinoctial, *nearly* in the ſame Poſition as on his Map.

And the Map may eaſily be placed in the ſame Poſition with the Heavens, at any Time; only by knowing what remarkable Star is then on the Meridian. Which to find, Obſerve the following Rule.

To the Right Aſcenſion of the Sun (as *per* Table) always *add* the ſuppoſed Hour of the Night, reckoning One o' Clock 13 Hours; Two 14, *&c.* and the Sum is the Right Aſcenſion of a Star that is then on the Meridian (always ſubſtracting 24 Hours if the Sum exceed 24.)

Thus

Thus for EXAMPLE.

The 1*ſt* *Nov.* 1730, at 49 Minutes paſt 8 at Night, I would know what Star is on the Meridian.

	h.	m.	
To —	15	: 10	the Sun's R. A.
Add —	8	: 49	the ſuppos'd Hour.

The Sum is 23 : 59, and looking then for this Sum among the Right Aſcenſions of the Stars in the general Catalogue, I find it ſtanding againſt the Tip of *Pegaſus*'s Wing, which is therefore then on the Meridian.

AGAIN.

The ſame Night later, at 15 Minutes paſt 4, I would know what Star is *then* on the Meridian.

	h.	m.	
To —	15	: 10	the Sun's R. A.
Add —	16	: 15	the Hour of the Morning.

And it gives 31 : 25 which being above a Day, accord. to the Rule.
Subſtract — 24 : 0

And the Rem. 7 : 25 is the Right Aſcenſion of Canicula, which is therefore then on the Meridian.

Thus, by finding the Star that is at any Time on the Meridian, you may eaſily hold your Map exactly in the ſame Poſition with the Heavens; and ſo you may learn all the other Stars that are adjacent to it, by comparing them

them together with your Map; which then anſwers the End, better than a Globe in that reſpect.

Thus by turning the Equinoctial Map inwards, into a Circular Form, and holding it before you towards the *South*, ſo as that a Line from the Star then on the Meridian in the Heavens, may firſt paſs thro' the correſponding Star in your Map, and the ſuppoſed Center of its Equinoctial, you will then ſee a perfect Repreſentation of all the principal Stars in the Concave Surface of your Map, and that in the ſame Situation with thoſe in the Heavens. And by ſuppoſing a Plane to cut the Center of your Equinoctial, parallel to the Horizon, all that are then above that ſuppoſed Plane, will be the Stars that are then viſible towards the *South*.

If any ſhould have occaſion to take the Meridian Altitude of a Star; the exact Time of its coming to the Meridian, is readily found by this

RULE.

Subſtract the Sun's R. Aſcenſion from the Right Aſcenſion of the Star, 24 Hours being firſt added to it when leſs than the Sun's: And the Remainder is the Hour of the Star's coming to the Meridian; all above 12 being the Hours of the next Morning.

Thus,

Thus, as in the former EXAMPLES *of the* 1ſt November, 1730.

	h. m.
The Right Aſcen. of *Pegaſus*'s Wing, is ——	23 : 59
From which if you ſubſtract the Sun's R. A. —	15 : 10
The Remainder is the Time ——	8 : 49 when

that Star will come to the Meridian.

	h. m.	
And ſo in the 2d Example —	7 : 25	being leſs than the
R. A. of the Sun, you muſt add —	24 : 0	to it
And from the Sum ——	31 : 25	
Subſtract the Sun's R. A. ——	15 : 10	
And the Remainder ——	16 : 15	anſwers to 15' paſt
	12 :	
	4 : 15	

4 in the Morning, the Time of Procyon's coming to the Meridian.

I have endeavoured, as near as poſſible, to make the Maps conformable to the Appearance; but as the Eye of a Spectator is always fix'd in the Center of the Heavens, ſo it is impoſſible to preſerve the ſame Situation exactly, when the Stars muſt be laid down on a Plane: The Stars in the *Northern* Map that are neareſt the Equinoctial being ſomewhat diſtorted; as on the other Hand, are thoſe of the Equinoctial Map that are neareſt the Pole; as may eaſily be diſcerned by comparing them with the Heavens.

But this will prove no ways inconvenient to a Learner, if he take Care to compare

thoſe Stars that are neareſt the Pole with the *Northern Map*, and ſuch as are neareſt the Equinoctial, with the *Equinoctial Map*. Theſe being in both Maps, nearly in the ſame Situation with thoſe in the Heavens.

Thus, by a frequent comparing the Stars in the Maps, with thoſe in the Heavens, any Perſon may very readily and eaſily be acquainted with them. And by now and then trying the Method of finding the Latitude as here propoſed, and comparing it with the common One, the diligent Obſerver will not only be more expert in the Calculation, but alſo confirm'd in the Truth of it, and that he may ſafely truſt to it in Caſe of any Exigency or Diſtreſs.

THE

The Particular Table of *Northern* Stars.

		Ang. of Poſition, when loweſt	*'s Diſt. from N. Pole	Diſtance from each oth.	Co. Ar. of the Sine of diſt. of *
		1ſt Propor.	2d.	2ce in 1ſt.	1ſt.
		° ′ ″	° ′ ″	° ′ ″	
75	*The Tip of* Peg's *Wing.*	100 27 42	76 18 14		
11	Mandibula	73 6 10	86 59 0	43 1 0	,166086
11	Mandibula	83 31 9	86 59 0		
18	Orion's *left ſhoulder*	93 45 8	83 55 10	35 37 26	,234733
18	Orion's *left ſhoulder*	92 11 12	83 55 10		
27	*The little Dog* Procyon	87 22 50	84 6 12	33 25 38	,258945
27	*The little Dog*	75 48 51	84 6 12		
30	*The Lyon's Heart*	97 45 11	76 44 48	37 22 5	,216859
30	*The Lyon's Heart*	73 38 24	76 44 48		
44	*Arcturus*	93 42 30	69 23 0	59 46 4	,063490
44	*Arcturus*	91 13 20	69 23 0		
54	*Serpentarius's Head*	73 36 31	77 13 38	48 6 52	,128147
54	*Serpentarius's Head*	94 31 42	77 13 38		
58	*The Eagle*	79 9 37	81 49 3	33 31 47	,257770
58	*The Eagle*	86 54 51	81 49 3		
65	*Pegaſus's* Mouth	88 51 30	81 19 6	28 3 21	,327596
65	*Pegaſus's Mouth*	78 43 5	81 19 6		
75	*The Tip of* Peg's *Wing*	93 49 33	76 18 14	36 43 9	,223375

The Particular Table of *Southern* Stars.

		Ang. of Position, when loweſt	*'s Diſt. from N. Pole	Diſtance from each oth.	Co Ar. of the Sine diſt. of *
		1ſt Propor.	2d.	2ce in 1ſt.	1ſt.
		° ' "	° ' "	° ' "	
4	*The* Ṡ. *in Whale's Tail*	88 59 30	109 27 54		
17	Orion's *left Foot*	107 35 4	98 32 27	66 24 2	,037931
17	Orion's *left Foot*	85 56 0	98 32 27		
29	Hydra's *Heart*	95 45 15	97 30 48	62 31 26	,051977
29	Hydra's *Heart*	96 51 52	97 30 48		
40	*The* Virgin's *Spike*	87 7 50	99 45 14	58 27 30	,069428
40	*The* Virgin's *Spike*	116 38 34	99 45 14		
51	*The* Scorpion's *Heart*	78 5 7	115 48 11	45 53 45	,143830
51	*The* Scorpion's *Heart*	88 34 0	115 48 11		
59	*The* N.*Horn of the Goat*	112 21 15	103 18 33	55 8 13	,085911
59	*The* N.*Horn of the Goat*	122 28 58	103 18 33		
71	*Fomahaut*	73 19 43	121 1 40	40 43 55	,185405

In the *Goat*'s-*Horn* there are two ſmall Stars, *North* and *South* of each other, the Nothermoſt of which is really a double Star.

Note therefore, that it is the Weſtermoſt or preceeding of the double Star, that is uſed in the Table above.

The

The General Catalogue of all the Principal STARS, 1731.

N°.	Names of the Stars.	Declination ° ' "		Magnitude	R. Asc. H. M.	Diff. *Dec.* in 72 Years Add or Sub. '
1	The N in the Whales Tail	S	10 19 4	3	0 6	S 24
2	The B in the Phœnix's Neck	S	43 43 0	2	0 8	S 21
3	The Breast of Cassiopæa	N	55 5 1	2	0 26	A 24
4	The S in the Whales Tail	S	19 27 54	2	0 30	S 24
5	The North Star	N	87 52 24	3	0 38	A 24
6	The Girdle of Andromeda	N	34 10 47	2	0 55	A 23
7	The Knee of Cassiopæa	N	58 50 18	3	1 9	A 23
8	*Acarner* in Eridanus	S	58 38 0	1	1 27	S 22
9	Andromeda's left Foot	N	41 1 17	2	1 48	A 21
10	The brightest in Aries	N	22 10 30	3	1 52	A 21
11	The B in Whales jaw *Mandib.*	N	3 1 0	3	2 49	A 18
12	Medusa's Head	N	39 54 3	2	2 51	A 18
13	The brightest in Perseus	N	48 52 47	2	3 5	A 17
14	The brightest of the 7 Stars	N	23 14 37	3	3 32	A 14
15	The Bull's Eye *Aldebaran*	N	15 56 11	1	4 21	A 10
16	The Goat *Capella*	N	45 41 50	1	4 57	A 7
17	Orion's left Foot	S	8 32 27	1	5 2	S 6
18	Orion's left Shoulder	N	6 4 50	2	5 11	A 6
19	The 1st in Orion's Girdle	S	0 31 56	2	5 18	S 4
20	Orion's right Knee	S	9 47 46	2	5 35	S 3
21	Auriga's right Shoulder	N	44 53 23	2	5 40	A 2
22	Orion's right Shoulder	N	7 19 24	2	5 41	A 2
23	*Canobus*	S	51 37 0	1	6 19	A 2
24	The brightest in Gem. Feet	N	16 35 26	2	6 22	S 2
25	The great Dog *Sirius*	S	16 21 16	1	6 33	A 4
26	The first Twin *Castor*	N	32 26 31	2	7 17	S 8
27	The little Dog *Procyon*	N	5 53 48	1	7 25	S 9
28	The second Twin *Pollux*	N	28 38 42	2	7 29	S 9
29	Hydra's Heart	S	7 30 48	1	9 14	A 18
30	The Lion's Heart *Regulus*	N	13 15 12	1	9 54	S 20

N°.	Names of the Stars.	Declination ° ' "		Magnitude	R. Asc. H. M.	Diff. Dec. in 72 Years Add or Sub. '
31	The Lion's Neck	N	21 10 56	2	10 5	S 21
32	The Southern Pointer	N	57 48 55	2	10 45	S 23
33	The Northern Pointer	N	63 12 3	2	10 47	S 23
34	The Lion's Loins	N	21 59 4	2	11 0	S 23
35	The Lion's Tail	N	16 3 50	2	11 51	S 24
36	The great Bear's Hip	N	55 11 17	2	11 40	S 24
37	The Centaur's right Foot	S	58 6 0	1	11 59	A 24
38	The great Bear's Rump	N	58 32 54	2	12 2	S 24
39	The 1st * in his Tail	N	57 27 22	2	12 42	S 24
40	The Virgin's Spike	S	9 45 14	1	13 11	A 23
41	The 2d * great Bear's Tail	N	56 20 35	2	13 13	S 23
42	The Centaur's left Knee	S	59 9 0	2	13 33	A 22
43	The tip of the gr. Bear's Tail	N	50 39 42	2	13 37	S 22
44	*Arcturus*	N	20 37 0	1	14 3	S 21
45	The South Balance	S	14 54 19	3	14 36	A 19
46	The B guard little Bear	N	75 14 42	3	14 52	S 17
47	The B in the Beam of Libra	S	8 22 27	3	15 3	A 17
48	The Northern Crown	N	27 37 56	1	15 23	S 15
49	The B in the Serpent's Neck	N	7 17 17	3	15 31	S 14
50	The N in Serpentar. L. Ha.	S	2 58 55	3	16 1	A 12
51	The Scorpion's Heart *Antares*	S	25 48 11	1	16 13	A 11
52	Hercules's Head	N	14 42 27	3	17 2	S 6
53	The Scorpion's Tail	S	36 51 59	3	17 15	A 5
54	Serpentarius's Head	N	12 46 22	3	17 22	S 4
55	Draco's Eye	N	52 31 2	3	17 24	S 4
56	The Harp *Lyra*	N	38 33 16	1	18 28	A 3
57	The Eagle's Tail	N	13 29 10	3	18 53	A 5
58	The B * in the Eagle	N	8 10 57	1	19 38	A 10
59	The N Horn ♑ Wn. doub. *	S	13 18 33	3	20 3	S 12
60	The B in the Peacock's Head	S	57 41 0	2	19 54	S 12
61	The Swan's North Wing	N	44 29 55	3	19 36	A 10
62	The Breast of the Swan	N	39 24 56	3	20 13	A 13
63	The Tail of the Swan	N	44 20 33	2	20 32	A 15
64	Aquarius's left Shoulder	S	6 43 45	3	21 17	S 18
65	Pegasus's Mouth	N	8 40 0	3	21 31	A 19

N°.	Names of the Stars.		Declination ° ' "			Magnitude	R. Asc. H. M.		Diff. *Dec.* in 72 Years Add or Sub.	
66	The Goat's Tail E of the 2	S	17	18	40	3	21	32	S	19
67	The Crane's Head	S	38	47	0	2	21	33	S	19
68	The Crane's left Wing	S	48	14	0	3	21	52	S	19
69	Aquarius's right Shoulder	S	1	36	35	3	21	52	S	20
70	The B in the Crane's Tail	S	47	31	0	2	22	25	S	22
71	Fomahaut	S	31	1	40	1	22	43	S	23
72	Pegasus's Leg *Scheat*	N	26	37	35	2	22	50	A	23
73	Pegasus's Shoulder *Markab*	N	13	45	30	2	22	51	A	25
74	Andromeda's Head	N	27	36	5	2	23	54	A	24
75	The tip of Pegasus's Wing.	N	13	41	0	2	23	59	A	24

Note, N Signifies North.
S - - - - South.
B - - - - Brightest.

A Table of the Sun's Right---

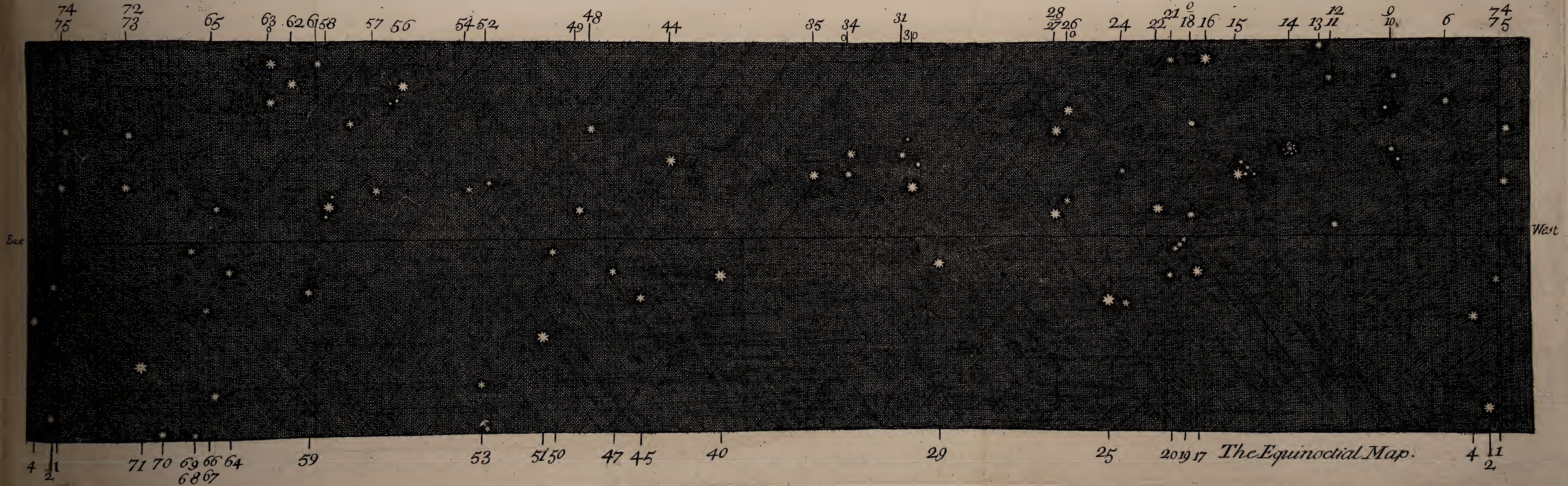
	Jan.	Feb.	March	April	May	June
D.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
1	19 36	21 45	23 31	1 24	3 17	5 21
2	19 40	21 49	23 35	1 28	3 21	5 25
3	19 45	21 53	23 39	1 32	3 25	5 29
4	19 49	21 56	23 42	1 35	3 29	5 33
5	19 53	22 0	23 46	1 39	3 33	5 37
6	19 58	22 4	23 50	1 42	3 36	5 42
7	20 2	22 8	23 53	1 46	3 40	5 46
8	20 6	22 12	23 57	1 49	3 44	5 51
9	20 10	22 16	0 1	1 53	3 48	5 55
10	20 15	22 20	0 4	1 57	3 52	5 59
11	20 19	22 24	0 8	2 1	3 56	6 3
12	20 23	22 27	0 12	2 4	4 0	6 7
13	20 28	22 31	0 15	2 8	4 4	6 11
14	20 32	22 35	0 18	2 12	4 9	6 15
15	20 36	22 39	0 22	2 16	4 13	6 19
16	20 40	22 43	0 26	2 20	4 17	6 24
17	20 44	22 46	0 29	2 24	4 21	6 28
18	20 48	22 50	0 33	2 28	4 25	6 32
19	20 52	22 54	0 37	2 32	4 29	6 36
20	20 56	22 58	0 41	2 36	4 33	6 40
21	21 0	23 2	0 44	2 39	4 37	6 44
22	21 4	23 5	0 48	2 43	4 41	6 48
23	21 9	23 9	0 52	2 47	4 45	6 52
24	21 13	23 13	0 55	2 50	4 49	6 57
25	21 17	23 16	0 59	2 54	4 53	7 01
26	21 21	23 20	1 3	2 58	4 57	7 5
27	21 25	23 24	1 6	3 2	5 2	7 9
28	21 29	23 28	1 9	3 6	5 6	7 13
29	21 33		1 13	3 10	5 9	7 17
30	21 37		1 17	3 13	5 13	7 21
31	21 41		1 21		5 17	

-- Ascension in Hours and Minutes.

	July		Aug.		Sept.		Oct.		Nov.		Dec.	
D.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M
1	7	25	9	28	11	22	13	11	15	11	17	18
2	7	29	9	32	11	26	13	14	15	15	17	23
3	7	33	9	36	11	29	13	18	15	19	17	27
4	7	37	9	39	11	33	13	22	15	23	17	31
5	7	41	9	42	11	36	13	25	15	27	17	36
6	7	46	9	46	11	39	13	29	15	31	17	40
7	7	50	9	50	11	43	13	33	15	35	17	45
8	7	54	9	54	11	47	13	37	15	39	17	49
9	7	58	9	58	11	50	13	40	15	43	17	53
10	8	2	10	2	11	54	13	44	15	48	17	58
11	8	6	10	5	11	58	13	48	15	52	18	2
12	8	10	10	9	12	1	13	51	15	56	18	6
13	8	14	10	13	12	5	13	55	16	0	18	11
14	8	18	10	17	12	9	13	59	16	4	18	16
15	8	22	10	21	12	13	14	3	16	9	18	20
16	8	26	10	24	12	17	14	7	16	13	18	24
17	8	30	10	28	12	20	14	11	16	17	18	29
18	8	34	10	32	12	24	14	15	16	22	18	33
19	8	37	10	35	12	28	14	19	16	26	18	38
20	8	41	10	39	12	31	14	23	16	30	18	42
21	8	45	10	42	12	35	14	26	16	34	18	47
22	8	49	10	46	12	38	14	30	16	39	18	51
23	8	53	10	50	12	42	14	34	16	43	18	56
24	8	57	10	53	12	46	14	38	16	47	19	0
25	9	1	10	57	12	49	14	42	16	52	19	5
26	9	5	11	0	12	53	14	46	16	56	19	9
27	9	9	11	4	12	57	14	50	17	1	19	13
28	9	13	11	8	13	0	14	54	17	5	19	18
29	9	17	11	12	13	4	14	59	17	9	19	22
30	9	21	11	15	13	8	15	3	17	14	19	27
31	9	25	11	19			15	7			19	31

FINIS.

The Northern Map.



The Equinoctial Map.